URBAN WATER SUPPLY SYSTEM PERFORMANCE ASSESSMENT

(THE CASE OF HOLETA TOWN, ETHIOPIA)

BY

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Declaration

I declare that the work in the thesis entitled **"Urban Water Supply System Performance Assessment: the Case of Holeta Town, Ethiopia"** was composed by myself under the supervision of Dr. Brook Abate in the College of Architecture and Civil Engineering, Addis Ababa Science & Technology University in the year 2018. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another Degree or Diploma at any University.

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Approval Sheet

This is to certify that the thesis prepared by **Mr. Rata Fikadu Ayala** entitled **"Urban Water Supply System Performance Assessment: the Case of Holeta Town, Ethiopia"** and submitted in fulfillment of the requirements for the Degree of Master of Science in Hydraulic Engineering complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. The adequate and reliable water supply in developing towns of Ethiopia is becoming a challenge for most water utilities. The objective of this research was to assess the problem of Holeta town water supply and distribution system. This study assessed the performance of Holeta town water supply system based on main performance indicators namely high water loss, water quality, inadequate water supply coverage, satisfaction of customers and operation and maintenance. The distribution system is evaluated by running the system of water supply by GEMS V8i.The water samples were collected from all existing water sources, reservoirs, collection chambers and household taps and water quality test was conducted for water quality parameters namely Total dissolved solid, residual chlorine, coli form, hardness, turbidity and PH. Field observations were made to gather data and observe the water supply system has high water loss, water quality problem, inadequate water supply coverage, satisfaction of customers and operation and maintenance problems on site. The result showed that water loss was found to be 13.39%. The water supply coverage was very low which covers only 52.57%. Besides water demand and supply of Holeta town were not balanced, the water quality tests showed poor water quality result when compared to the standard set on the Ethiopian (National) and WHO Water Quality standards. Hence, it can be concluded that there is operation and maintenance problem and the water supply system performance is low. Holeta Water supply office should gather the X, Y, coordinates of its Water supply distribution system from source to customer water meters to know and evaluate hydraulic system using Water GEMS with GIS integrated software, for more precise and faster way of in demand allocation. it needs to be documented in a well-organized way .In general ,All relevant documents, feasibility studies, Bore Hole history, manufacturer manuals and detail designs, as built drawings of all existing water supply system components for the sources, reservoirs, pump houses etc need to be documented in a well-organized way and should be available in the water utility office for future reference is strongly recommended.

Key words: *Arc GIS 10.3, MS Excel, Water GEMS V8i, Holeta water supply coverage, Holeta, water supply network, assessment of Water Quality, assessment of water loss.*

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List of Acronyms

a.s.l.	Above sea level
AWWA	American Water Works Association
Ave.	Average
BH	Borehole
CT	Contact Time
CSA	Central Statistical Agency
CSAE	Central Statistics Agency of Ethiopia
DPD	Diethyl Phenyl Damien
EEPCO	Ethiopian Electric Power Corporation
E.C	Ethiopian Calendar
ERA	Ethiopian Roads Authority
EC	Electrical Conductivity
EDTA	Ethylenediaminetetra acetic acid
FCC	Fecal coli form
GEMS	Geospatial Engineering Modeling System
GPS	Global Positioning System
GIS	Geographical Information System
HC	House Connection
HCU	House Connection Users
HDPE	High Density Poly Ethel yen pipe
Hrs	hours
HTP	House tap connection
LCB	Lahore Cantonment Board
L/c/d	litres per capita per day
L/s	litres per second

m	Meters
m/s	Meter per second
m^3	Cubic meter
MoWR	Ministry of Water Resource
mg/l	Milligram per litter
M3/day	cubic meters per day
m3/hr	cubic meters per hour
ml	Milliliter
°C	degrees centigrade
NTU	Nephelometric Turbidity Units
NRW	Non-Revenue Water
PHF	Peak Hour factor
PTU	Public tap users
PH	Power of Hydrogen ion scale
PVC	Poly vinyl Chloride
TNTC	Too Numerous To Count
YCO	Yard Connection Own
YCS	Yard Connection Shared
YTC	Yard Tap connection
YTU	Yard Tap Users
UfW	Unaccounted for Water
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background

Water is an essential and life-sustaining natural resource and is critical for the survival of all living organisms, food production and economic development. Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. The sustainable provision of adequate and safe drinking water is the most important of all Public services (Dassalew, 2017).

The adequate and reliable water supply in developing towns of Ethiopia is becoming a challenge for most water utilities. Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time (Asmelash, 2014).

Water is the primary need to sustain life every citizen in the country has the right to have access to potable water. Access to safe drinking water supplies and sanitation services in Ethiopia are among the lowest in Sub-Saharan Africa (Seifu, 2012).

Access to clean and safe drinking water is a fundamental human requirement. However, in many areas of the world natural water sources have been impacted by a variety of biological and chemical contaminants. The ingestion of these contaminants may cause acute or chronic health problems. to prevent such illnesses, many technologies have been developed to treat, disinfect and supply safe drinking water quality (Dawit, 2015).

Provision of safe and adequate water supply services is necessary components for sustainable development. A water supply system is a collection of water transport structures, pumping stations, and water treatment and storage facilities that are managed to supply the desired amount of water with the desired quality to consumers. The estimated water supply service level of Ethiopia in terms of coverage, quantity, quality and reliability is very low (Desalegn, 2015).

The provision of adequate and reliable water supply in developing countries is becoming a challenge for most water utilities especially public service providers. Water demand has been increasing drastically in these countries due to many factors including population growth as a result of rural to urban migration As a consequence, in many countries public service utilities have failed to provide consumers with adequate water supply (Kimey, 2008). Water demand has been increasing drastically in urban due to many factors including population growth as a result of from rural to urban migration (Desalegn, 2015).

Apart from service coverage, there are other problems that affect public service providers such as high unaccounted for water (UfW) and financial problems due to a combination of low tariff, poor services, poor consumer records and inefficient billing practices. In many countries public service utilities have failed to provide consumers with adequate water supply and sanitation services. Apart from service coverage, there are other problems that affect public service providers such as high Unaccounted for Water (UfW) (Kimey, 2008).

Urban water supply utilities in developing countries are faced with challenges of low service coverage and high unaccounted for water (UFW). UFW reduces the water Available to customers, and results in loss of revenue for the water utility (UFW) (Jessy, 2009).

Regular bacteriological assessment of water supply sources and storage in conjunction with sanitary and hygienic survey at the household level for drinking water should be planned and conducted to monitor the impact of using latrine and hygienic facilities on drinking water supply quality. Sources of contamination of water and then preventive strategies could be defined from regular assessment.

Access to safe and adequate water supply is a universally recognized human right, which has special significance to the survival of humanity. Adequate water supply is defined as having reasonable access to safe water supply. Performance of water utilities can be assessed by many factors including accessibility and reliability of water supply, affordability of services, and customer satisfaction. In many developing countries, however, the public service providers have failed to provide consumers with adequate water supply and sanitation services. The existing problems of inadequate service provision is exacerbated by the fact that population growth and mounting pressure of increasing urbanization have offset much of the gains in service coverage (Desalegn, 2015).

Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. Water supply systems in urban areas are often unable to meet existing demands and are not available to everyone rather some consumers take disproportionate amounts of water and the poor is the first victim to the problem.

Providing safe water supply to the urban cities of developing countries is one of the major challenges in meeting with respect to water supply (Baieti, 2006).

Moreover, managing and reducing losses of water at all levels of a distribution system remains one of the major challenges facing many water utilities in most developing countries including Ethiopia. Water supply coverage provides a picture of the water supply situation of one specific country or city and helps to compare one country with others and the inter and intra city distribution with in specific country. According to the Global Water Supply and Sanitation Assessment 2000 Report, the African capital cities are having 43% house connection or yard tap, 21% served by public tap while 31% of the population are un-served (WHO, 2000).

A well performing urban water supply system should provide water supply for human being and livestock consumption, for industrial and other uses in terms of coverage, quantity, reliability and acceptable quality taking the existing and future realities of the city in to consideration.

This research paper was assess and evaluate the performance of Holeta water supply system in terms of main performance indicators such as water supply coverage, water quality, and water Loss, hydraulic performance and customer satisfaction and recommend solutions for improving the water supply service.

1.2.Statement of the Problem

Holeta town has water supply and demand related problems. Presently Holeta faces presently a serious deficit in the water supply due to increased population and expanded economic actually in and around the subsystems.

Assessment of the performance of urban water supply system is to improve the water supply service level and the main activities is to identify the gap or to fill the gap between the demand and existing water supply system to analyze the distribution system is working as per the design or not. Best performing systems should provide safe, sufficient and affordable water supply service, with low water loss and good quality of water which fulfills national and international standards.

In addition to insufficient water supply coverage, high water loss and water quality issues are the major challenges of Holeta water supply system. Weakness and strengths of the system is not identified. As the water lost, the water utility is losing revenue. it is not known where and how much water is lost from existing Water supply system.

There are kebeles in the town which are out of the reach of distribution pipes and the town with distribution pipes but without water most of the time. In addition to insufficient water supply coverage, high water loss and water quality issues are the major challenges of Holeta water supply system. to assess Holeta water supply system hence, this research identify the gaps between the demand and existing water supply system, the town with distribution pipes but without water most of the time ,evaluate the distribution system, assess the water quality and identify how much water is lost per yearly bases.

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1.3. Objectives of the Study Area

1.3.1 General Objective

- The general objective of this research is to assess the performance of Holeta town water supply system.

1.3.2 Specific Objectives

- To assess the existing water supply and demand of the town and the level of Customer's Satisfaction towards the water supply service.
- To evaluate the hydraulic performance of water supply distribution system by Water GEMSV8i.
- To determine the water quality level and compare the results with national and international standards.
- To determine the amount of water loss and water loss trends of the past years and give clue for possible causes of water loss.

1.4.Research Questions

The general and specific objectives of the study would be achieved by way of seeking answers to the following questions.

- What is the present water supply coverage of Holeta town?
- Are customers satisfied with the service?
- What is the amount of water produced and distributed to the distribution system?
- What is the hydraulic performance of the water supply system concerning pressure and Velocity?
- Do the drinking water quality parameter of Holeta Town fit the Guide lines set by WHO standard and Ethiopian standard?
- How much water is lost compared to the water produced?
- What are the main causes of water loss?

1.5.Significance of the study

From the study, it is expected that the deficiencies of the water supply system which encompass the estimate of unaccounted water and causes for the water loss is assessed and known, water supply coverage and water quality level is determined. Besides customer satisfaction towards the service, operation and maintenance condition, to develop an appropriate performance assessment system for evaluation and efficiency improvement of urban water distribution systems in the Holeta Town.

The purpose other views to assess knowledge gaps and to identify future research needs. to assess and analyze results and estimates will in turn contribute to know the overall performance level of the system.

Besides, the results help decision makers and especially the town water utility (water supply service office) in planning of future expansions and to know areas of water loss and develop corrective measures to reduce the high water loss, improve coverage, service reliability and water quality so as to make the system more efficient and increase water supply service level. It also gives a clue for further research.

CHAPTER TWO

2. LITERATURE REVIEW

Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. Water supply system in urban areas are often unable to meet existing demands and are not available to everyone rather some Consumers take disproportionate amounts of water and the poor is the first victim develop and expand water supple projects and one of the difficulties among two other is managing and Reducing losses of water at all levels of a distribution system. the overall shortage of water in many cities are faced a problem in distributing the available water impartially among the residents besides, to low coverage, water loss (physical loss) in urban water supply is accounted to more than 50% the supplies that mainly arise from; Leakage of pipes, joints and valves, Over flowing service reservoirs and Wastage of water thought illegal connection and Unmetered house connections (Melaku, 2015).

2.1.Urban Water Demand and Coverage

2.1.1. Urban Water Coverage

Water supply coverage provides a picture of the water supply situation of one specific country or city and helps to compare one country with others and the inter and intra city distribution with in specific country. The percentages of population with or without piped water connection are a relevant indictor to compare the coverage of water supply in urban areas (Melaku, 2015).

In evaluating the water supply coverage the focus was on the volume of consumption and level of water connection as these are highly related to the issue of water loss. After evaluating the distribution of water supply coverage in the town, the water loss from the distribution system of the utility was analyzed (Asmelash, 2014).

2.1.2. Performance indicators of urban water supply systems

The major challenges of urban water supply systems in developing countries are low water supply service coverage, unavailability of sufficient water at all times, very high amount of water loss which ranges up to 50% of amount of water produced and absence of quality water which meets national or international drinking water standards (Desalegn, 2015).

The following are suggested performance indicators for evaluating urban distribution systems: - Water resources performance, Water resources availability, Pressure complaints, Quality of service performance, Continuity of supply. Moreover, the service providers in developing countries are often confronted with financial problems due to a combination of low tariffs, poor consumer records and inefficient billing and collection practices. As a result, the quality of water services that is actually delivered to the consumer, if they are connected at all, is low. The public water utilities, which are likely to remain responsible for service provision for many years to come do not have satisfactory performance and provide inadequate services to their customers (Desalegn, 2015).

2.1.3. Water resources performance

Water supply systems in urban areas are often unable to meet existing demands and are not available to everyone rather some consumers take disproportionate amounts of water and the poor is the first victim to the problem, Addis Ababa the capital city of Ethiopia is one of the developing country cities suffering from shortage of water supply with especially acute in the urban areas of a city (Asmelash, 2014).

2.1.4. Operational performance

Operation and maintenance of a water distribution system is highly dependent on the way the system is designed and constructed (including modifications and repairs), and problems in these phases can result in major operation and maintenance problems. as per kimey (2008), the quality of service can also be assessed by assessing the accessibility of water, reliability of water services, water quality, customer-operator relations and the affordability of the service provision. Factors that should be considered in assessing the accessibility of water supply include supply coverage and production capacity to meet consumer demand. The type of house hold main water source and per capita water use are also needed to study. The reliability of the service can be studied by investigating the duration of water supply and down time period (Desalegn, 2015).

2.1.5. Quality of service performance

The provision of adequate supplies potable water for use in urban area as in developing countries is crucial for the well-being of the people. The demand for such supplies in the developing countries has been on the increase over time as a result of rising standards of living that occur with economic progress and population increase resulting from natural growth and rural urban migration and rising per capital income, in many developing countries public water service providers have failed to provide Consumers with adequate water supply and sanitation services (Desalegn, 2015).

A study set out to assess the performance of two urban water supply utilities in Tanzania shows there are serious water supply problems in the districts under study. The assessment was based on two main indicators which are the quality of service and unaccounted for water. The quality of the service and UFW has been cited as some of the major factors which reflect the performance of many water utilities. Poor service quality as measured by the water quality, billing efficiency and customer satisfaction affects consumer willingness to pay and consequently the performance of the water supply utility. Methods used in the study included documentary review, house hold questionnaires, key informant interviews and field observations. The results show that accessibility and reliability of water supply in Muheza town is inadequate compared to Korogwe town. On average customers receive water for 8 hours per day in Korogwe and 5hours per day in Muheza. Water supplied by the respective utilities in the two districts is far below the total demand. More than 80% of customer complaints in both towns were about water quality, water shortage and customer relations. Poor billing practices and old infrastructure have resulted in high UfW of 42%in Korogwe and 47% in Muheza (Kimey, 2008).

2.2.Types of demands

When determine the water supply scheme of a city or town we have to know the total yearly, monthly, daily as well as hourly demand variation in the demand rates. There are so many factors involved in determining of demand that make the actual demand estimation unreliable. However, the demand for various purposes is divided under the following categories: Domestic water demand (the amount of water needed for drinking, food preparation, washing, cleaning, bathing and other miscellaneous domestic purposes), Non domestic demand, Business or commercial water demand, Industrial water demand and Fire demand. One of the difficulties faced by the water service office is determining the accurate water demand if the town as the consumption during the past years that have been used as a base is far below the a actual demand due to shortage of water (Melaku, 2015).

2.2.1. Non-Domestic Water Demand

Non-domestic water demand (The water required for schools, hospitals, health centre offices, government offices and services, religious institutions and other public facilities) was also determined

Systematically. It can be broadly classified into the following major categories: Institutional water demand, Commercial water demands and Industrial water demand (Holeta Design Report, 2009).

2.2.2. Educational Water Demand

The water demand for educational institutes is classified into day schools and boarding schools and this includes the water required for schools, colleges and training centres located within the town. It depends on the number of students, teachers and other supporting staff in the school (Holeta Design Report, 2009).

2.2.3. Non-Revenue Water

Non-revenue water includes water losses in the water supply system, illegal connections overflow from reservoirs, improper metering and losses in treatment plant. The amount is expressed as percentage of the sum of domestic, public and industrial demands covered from the water supply system. The percentage usually varies from 15 to 50 percent depending on the age of the pipes and complexity of the system (Welday, 2005).

2.2.4. Industrial Water Demand

Currently four small industries related to construction and flower culturing is utilizing about $30m^3$/day from town's water supply service. Also, during the project period, some small to medium scale industries are expected to be established in the town mainly the agro-industry such as, meat processing, hide and skin processing, honey and wax processing, flourmill and edible oil mills as the area is reach with agricultural products. Factors as potential for development and proximity to market are also considered in determining the potential for possible industries to be established in the future (Holeta Design Report, 2009).

2.2.5. Adjustment for Climate and socio economic condition

Holeta with a mean annual precipitation of 1367 mm belongs to Group C (medium growth rate) as per the design criteria for adjustment of climate and socio economic condition. Thus, an adjustment factor of 1.0 was taken (Ministry of Water Resource, 2006).

2.2.6. Fire Fighting Demand

The annual volume required for firefighting purpose is small. However, during periods of need, the demand may be exceedingly large and in many cases govern the design of distribution, storage and pumping requirements. In this case the firefighting water requirements are considered to be met by stopping supply to consumers and directing it for this purpose. This demand is taken care of by increasing the volume of storage tanks by 10 % .Firefighting flows are usually accounted for in maximum daily flow. There are several time related demands that should be considered in the model such as seasonal demands, weekly demands, population growth and industrial demands. Seasonal Demands such as hot dry summers cause increase lawn watering (Amdework, 2012).

2.3. Water Demand Factors

2.3.1. Average Water Demand

The average daily water demand is the sum of the domestic, non-domestic and unaccounted for water which is used to estimate the maximum day & the peak hour demand. The average day demand is used in economic calculations over the projects lifetime. One of the difficulties faced by the water authority is determining the accurate water demand of the city as the consumption during the past years that should have been used as a base is far below the actual demand due to the shortage of water (Holeta Design Report, 2009).

2.3.2. Maximum Day Water Demand

The water consumption varies from day to day. The maximum day water demand is considered to meet water consumption changes with seasons and days of the week. The ratio of the maximum daily consumption to the mean annual daily consumption is the maximum day factor. The proposed maximum day factor usually varies between 1.0 & 1.3 (Holeta Design Report, 2009).

2.3.3. Peak Hour Water Demand

The peak hour demand is the highest demand of any one hour over the maximum day. It represents the daily variations in water demand resulting from the behavioral patterns of the local population

Experience clearly demonstrates that the peak hour factor is greater for a smaller population. the recommended peak hour factors in relation to population size.

Table 2-1 Recommended Peak Hour Factors

Population Range	Peak hour factor
<20,000	2
20,001 to 50,000	1.9
50,001 to 100,000	1.8
>100,000	1.6

Source-(Urban Water Supply Design Criteria by Ministry of Water Resources, January 2006).

2.4.Water Demand and Consumption

One of the difficulties faced by the water service office is determining the accurate water Demand. The town as the consumption during the past years that have been used as a base is far below the actual demand due to shortage of water. Therefore Consumption of water for town is estimated based on the amount supplied rather than the actual demand. One of the difficulties faced by the water service office is determining the accurate water demand if the town as the consumption during the past years that have been used as a base is far below the a actual demand due to shortage of water . Consumption of water for town is therefore estimated based on the amount supplied rather than the actual demand .For these Reason estimates of the future demand by the water service office are found to be uncertain. People having in-house service that are estimated about 25% of the total population use water on Average between 40 and 60 litter per capita per day, while the remaining population with access to safe drinking water (75%) are served by yard connection and between 15 and 30 litter L/C/Day (Melaku, 2015).

2.4.1. Average daily per capital consumption

The volume of water consumed for domestic purpose has been aggregated to all Kebele of the town so as to analyses the distribution of the water supplies coverage among different localities. The annual consumption data has been converted to average daily per capita consumption using the number of population.

Water demand is defined as the volume of water requested by users to satisfy their needs. Water supply coverage provides a picture of the water supply situation of one specific country or city and helps to compare one country with others and the inter and intra city distribution with in specific country. The percentages of population with or without piped water connection are relevant indictor to compare the coverage of water supply in urban areas. Although the water supply coverage is better in urban areas while compared with the rural. The actual water supply coverage in cities of developing countries is very low while compared to the demand. The average domestic water supply coverage of the town is found to be 12.8 l/capital/day. This average per capita consumption is very low while compared with the country standard used for design purpose (30 to 50l/capital/day) and even it is lower than that of the minimum standard set by UN-Habitat as a basic need(20l/capital/days (Asmelash, 2014).

a household is considered to have access to improved drinking water if it has sufficient amount of water (20 liters/person/day) for family use, at an affordable price (less than 10% of the total household income), available to house hold members without being subject to extreme effort (less than one hour) a day for the minimum sufficient quantity), especially to women and children .On the other hand a minimum quantity of 25 liters of potable water per person per day provided at a minimum flow rate of not less than 10 liters per minute with the source being available Within 200 meters form a household and the supply not interrupted for more than seven days per Year (i.e. water should be available 98% of the time) is considered as a basic service for southern African cities' domestic water supply (Welday, 2005).

2.5. Population and Water Demand Projection

The current development plan for Holeta Town was prepared in 2008 by Oromia Regional state Urban Planning Institute. The development plan shows that there are areas allocated for residential, commercial, industrial and service-giving institutions. The 2014 Census undertaken by the Central Statistical Agency (CSA) gave the population of Holeta town as 40,528 in 2016. Hence, the population of Holeta is expected to show a medium growth rate (Holeta Design Report, 2009).

The knowledge of population forecasting is important for the design of any water supply scheme. The design is done on the basis of projected population at the end of design period. There are various methods of forecasting future population. They are: Arithmetic increase method, Geometric Increase Method, Incremental increase method, Decrease rate method, Simple graphical method, Logistic curve method and Ethiopian statistic authority method were used.

Table 2-2 population size

Year	Urban population			Rural population			Total Population		
2013	M	F	T	M	F	T	M	F	T
	15,995	16,644	32,639	1,297	1,436	2,733	17,292	18,080	35,372
2014	16,790	17,486	34,276	1,326	1,469	2,795	18,116	18,955	37,071
2015	17,558	18,298	35,856	1,356	1,503	2,859	18,914	19,801	38,715
2016	18,408	19,198	37,606	1,385	1,537	2,922	19,793	20,735	40,528

Source:-Central Statical Agency Ethiopia 2014

2.5.1. Modes of Services

Based on the available data obtained from the Holeta Water Supply Service during the field visit in August 2008, four major modes of service were identified for domestic water consumers. These are: House connections, Yard connections - private, Yard connections –shared, and public taps.

Table 2-3 CURRENT MODES OF SERVICES BY PERCENTAGE

Mode of Service	Percent of population served
HTC	3%
YTO	11%
YTS	4%
PT	72%
TOTAL	100%

Source :- (Holeta Design Report, 2009)

2.5.2. Population Distribution by Mode of Service

The percentage of population to be served by each mode of service will vary with time. The variation is caused by changes in living standards, improvement of the service level, changes in building standards and capacity of the water supply service to expand.

Table 2-4 POPULATION PERCENTAGE DISTRIBUTIONS BY MODE OF SERVICE

Mode of Service	Year						
	2015	2016	2017	2022	2027	2032	2037
HTC	3%	3.8%	4.3%	4.98%	5.65%	6.33%	7%
YTO	11%	13.2%	23.4%	25.98%	28.55%	31.13%	33.7%
YTS	4%	4.3%	5%	7%	9%	11%	13%
PT	72%	78.7%	67.3%	62.05%	56.8%	51.55%	46.3%
TOTAL	100%	100%	100%	100%	100%	100%	100%

Source :- (Holeta Design Report, 2009).

2.5.3. Per Capita Water Demand

The per-capita domestic water demand for various demand categories varies depending on the size of the town and the level of development, the type of water supply scheme, the socioeconomic conditions of the towns and the climatic condition of the area. The per capita water demand for adequate supply level has to be determined based on the basic human water requirements for various activities of demand category.

Table 2-5 BREAKDOWN OF PER CAPITA WATER DEMAND

Mode of Service	Year				
	2017	2022	2027	2032	2037
HTC	50.0	50.0	50.0	60.0	70.0
YTO	30.0	30.0	30.0	35.5	40.0
YTS	25.0	25.0	25.0	27.5	30.0
PT	20.0	20.0	20.0	22.5	25.0

Source: - (Holeta design report, 2009)

2.6. Customer satisfaction

Study of customer satisfaction is of prime importance in encouraging performance improvement of any service provider. This is true even in the case of government-owned organizations such as those which provide essential services such as water supply. In most developing countries, including Ethiopia, infrastructure services are provided by state-owned organizations. The requirements and satisfaction of customers are low on priority in government owned organizations, mainly due to lack of professional approach in customer services. The level of satisfaction is, therefore determined by the perceived performance of a company or utility, which is an evaluation of the delivered good or service viewed in the light of the consumers' needs. It is generally expected that a higher level of service quality is expected to lead to customer satisfaction and eventually to better customer loyalty and higher profits. As water demands pressures raise increasingly on the existing water supply system, many studies attempted to develop a general water supply system to assist decision makers to design more reliable systems for a long range operation period for customer satisfaction (Chung, 2007).

It was measured on a 10-pointLikert scale by asking respondents to rate the extent to which they were satisfied with overall service delivery by the utility, with1 being the lowest satisfaction rating and 10 being the highest rating. The data were recorded into five CS levels: 1–2 as very low satisfaction, 3–4 as low satisfaction, 5–6 as medium satisfaction, 7–8 as high satisfaction, and 9–10 as very high satisfaction (AWWA, 2013).

Water supply agencies as well as their regulators are becoming increasingly sensitive to customer protection issues and customers' opinions about the service quality and performance. Customer's satisfaction is closely related to acceptance and preferences of the customers. The extent to which a consumer is satisfied with a good or service is therefore determined by the perceived performance of the utility which is an evaluation of that good or service in the light of customers' needs (Omar, 2011). The research made by (Omar, 2011) to check whether the residents are satisfied or not with clean drinking water provided by Lahore (Pakistan) Cantonment Board (LCB) used main research questions that summarize the main aspects of clean drinking water. The research questions were overall satisfaction of people with the clean drinking water, aspects of the water that the customers have complaints against such as quality, quantity, continuity and price and on the satisfaction of the customers. Water is a lifeline whose importance is felt only when people cannot get enough of it. It is keeping this in mind that urban water distribution networks are designed to supply water for

Household customers as well as industrial concerns twenty four hours a day, three sixty five days of the year in order to satisfy the customers (Desalegn, 2015).

2.7. Hydraulic Performance Analysis of the Distribution System

A water distribution system is a pipe network which delivers water from single or multiple supply sources to consumers. Typical water supply sources include reservoirs, storage tanks, and external water supply at junction nodes such as groundwater wells. Consumers include both municipal and industrial users .The pipe network consists of pipes, nodes, pumps, control valves, storage tanks, and reservoirs.

The Water distribution model of Holeta town is used to illustrate the practical use of this approach in terms Pressure variation in distribution network is caused, among others, by changes of demand of users (Holeta Design Report, 2009).

Hydraulic analysis of flows and pressures in a distribution system has been a standard form of engineering analysis since its development by Hardy Cross in 1936. The demand usually reaches a peak in the morning when people are at home and preparing their Meal and its second peak in the evening Maximum water use and minimum water use, usually related to average water use by multiplication of peaking factors (Melaku, 2015).Water CAD views the water distribution system as a network link.

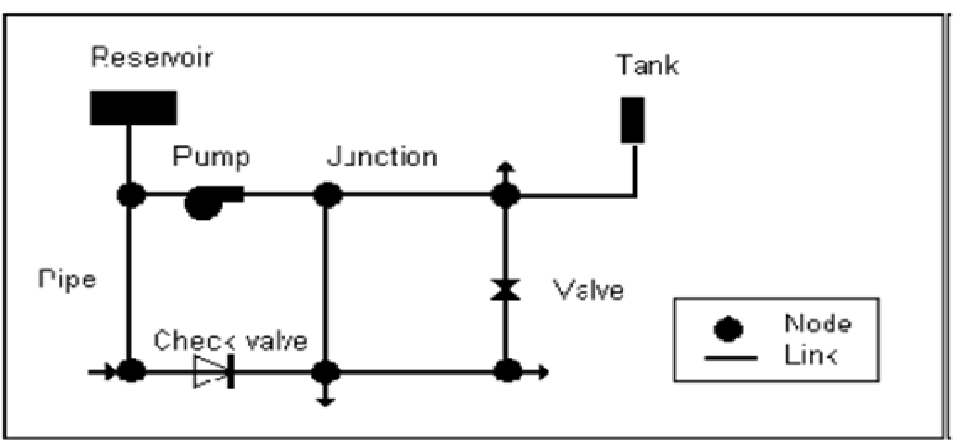


Figure 1 NODE-LINK REPRESENTATION OF A WATER DISTRIBUTION NETWORK (ADOPTED FROM WATER CAD, 2008)

2.7.1. Pipe Diameters Computation

After knowing the design discharges, the pipe diameters are assumed in such a way that the permissible velocities of flow in pipes remain within the permissible value (Amdework, 2012).

2.7.2. Roughness Coefficient

In the assess Hazen William coefficient which depends on the following: The type of material of the pipe, the roughness of the pipe, the age of the pipe and Diameter of the pipe was used (Amdework, 2012).

2.7.3. Calibration and Validation

Calibration is the process of comparing the model results to field observations and, if necessary, adjusting the data describing the system until model predicted performance reasonably agrees with measured system performance over a wide range of operating conditions. Even though the required data have been collected and entered into a hydraulic simulation software package, the modeler cannot assume that the model is an accurate mathematical representation of the system. The hydraulic simulation software simply solves the equations of continuity and energy using the supplied data; thus, the quality of the data will dictate the quality of the results. The accuracy of a hydraulic model depends on how well it has been calibrated, so a calibration analysis should always be performed before a model is used for decision making purposes (Amdework, 2012).

2.7.4. Calibration Standards

The following issues are raised frequently in the field of distribution system modeling:

Extent of calibration needed for various applications and Standards for calibration.

In 1999, the AWWA Engineering Computer Applications Committee developed and published a set of draft criteria for modeling. These were not intended as true calibration standards, but rather as a starting point for discussion on modeling needs. These criteria are summarized in the following.

Table 2-6ECAC calibration guidelines

Intended Use	Level of Detail	Type of Time Simulation	Number of Pressure Reading	Accuracy of Pressure Reading	Number of Flow Reading	Accuracy of Flow Reading
Long Range Planning	Low	Steady State or EPS	10% of Nodes	±5 psi (3.5m) for 100% Reading	1% of Pipes	±10%
Design	Moderate to High	Steady State or EPS	5%-2% of Nodes	±2 psi (1.4m) for 90% of Reading	3% of Pipes	±5%
Operations	Low to High	Steady State or EPS	10%- 2% of Nodes	±2 psi (1.4m) for 90% of Reading	2% of Pipes	±5%
Water Quality	High	EPS	2% of Nodes	±3 psi (2.07m) for 70% of Reading	5% of Pipes	±2%

Table 2-7 the number of pressure readings

Level of Detail	Number of Pressure Readings
Low	10% of Nodes
Moderate	5% of Nodes
High	2% of Nodes

2.7.5. Calibrating Hydraulic Network

Pressures are measured throughout the water distribution system to monitor the level of service and to collect data for use in model calibration. Pressure readings are commonly taken at hose bibs, and home faucets. if the measurements are taken at a location other than, a direct connection to a water main (for example, at a house hose bib), the head loss between the supply main and the site where pressure is measured must be considered. Models can be calibrated using one steady-state simulation, but the more steady-state simulations for which calibration is achieved, the more closely the model were represent the behavior of the real system.(Bentley, 2008).

2.8.Water quality

Water quality refers to assess the chemical, physical and biological characteristics of water. It is most frequently used by reference to a set of standards against which compliance can be assessed. Drinking water starts its journey within catchments, and is subsequently purified at treatment plants and delivered through distribution systems. Before deliver to distribution system it must meet the highest quality standards in terms of supporting beneficial uses or meeting its environmental standards in order to get Potable water , the water which is suitable for drinking and other purpose (Gurmessa,2015).

2.8.1. Physico- Chemical Water Quality Parameters

Drinking water quality acceptability is governed by limits of physico-chemical parameters. Because changes in water chemistry tends to be longer-term, chemical testing is not undertaken as frequently as microbiological analysis. The physico-chemical water quality parameters are the ones that are contributed by climatologically, hydrological and geological factors, they affect the Chemical and physical components of water (Desta, 2009).

2.8.2. Free Residual chlorine

Testing for residual chlorine is one of the most common tests used by water treatment. Through the residual chlorine test, the remaining chlorine amount is determined in water that has finished testing and is ready to be released in the distribution system. An ideal system supplies free chlorine at a concentration of 0.3-0.5mg/l. the chlorine that does not combine with other components in the water is free (residual) chlorine, and the break point is the point at which free chlorine is available for continuous disinfection (Selamawit, 2012).

The age of the water in the system since it was treated; Microbial re-growth within the distribution system; Reaction with corrosion by Most individuals are able to taste or smell chlorine in drinking-water at concentrations Well below 0.5 mg/l, and some at levels as low as 0.3 mg/l. The taste threshold for chlorine is below the health-based guideline value of 0.5 mg/l) (WHO, 2011).

Gaseous chlorine lowers the pH of water by reacting with water to form hypochlorous acid (HOCl), hydrogen ion and chloride ion. This reaction makes the water more corrosive. For low alkalinity water, the problem is greater because water has less ability to resist pH changes (Wiley, 2005).

2.8.3. Hardness

Hardness is a measure of both the magnesium and calcium contained in the water and it relates to how the water can mix with soap. Too little hardness makes the water more corrosive while too much reduces the effectiveness of soap. Water that has a higher hardness inhibits soap from lathering and more soap is consumed than normal. This is quite disappointing to users in rural Ethiopia where soap is actually a luxury when it is available, WHO (2011) suggests levels between 150 and 300mg/L. Hardness levels greater than 200 are considered poor, but tolerable, while hardness levels greater than 500 are generally considered unacceptable (Stantec, 2009).

Low hardness, specifically magnesium, may contribute to low magnesium intake and have Human health impacts, such as high blood pressure. Public acceptability of the degree of hardness of water may vary considerably from one community to another. The taste threshold for the calcium ion is in the range of 100–300 mg/l, depending on the associated anion, and the taste threshold for magnesium is probably lower than that for calcium. In some instances, consumers tolerate water hardness in excess of 500 mg/l (Selamawit, 2012).

2.8.4. Hydrogen Ion concentration (PH)

PH is classified as a secondary drinking water contaminant whose impact is considered aesthetic. However, the EPA recommends that public water systems maintain pH levels of between 6.5 and 8.5. (www.epa.gov/safewater/consumer/2ndstandards.html.Feb,2016).

Guideline for drinking water stated that the Standard limit of pH for drinking water should be between 6.5 - 8.5. It may be influenced by various factors and processes, including temperature, discharge of effluents, acid mine drainage, runoff and decay processes. Low PH levels cause severe corrosion of metals in the distribution systems while high pH values result in progressive decrease in the efficiency of the chlorine disinfection process (http://www.epa.gov/phscale.html.July, 2016).

It is not a regulated parameter for drinking water; pH is one of the key factors in the operational aspects of water supply (WHO, 2011).

2.8.5. Total dissolved solids

TDS is composed of inorganic salts and Organic matter, are usually tolerated up to 600mg/L but are unacceptable at levels greater than 1000mg/L (WHO, 2011). The level of total dissolved solids is directly related to conductivity and hardness since it is the measure of inorganic solids (sodium, chloride, magnesium, calcium and others) occurs in the water. Higher levels of TDS often alter the taste of water and cause dissatisfaction by the water consumers. It refers to materials suspended or dissolved in water or wastewater with high content is inferior and may be polluted (Seifu, 2012).

TDS levels are critical because electrical flow is necessary for corrosion to occur. Corrosion rates increase with increasing concentrations of TDS because water becomes a better conductor (Wiley, 2005).

The level of TDS rating less than300mg/l is excellent, 300mg/l-600mg/l is good, 600mg/l to 900mg/l is fair, 900mg/l -1,200mg/l is poor and above 1,200mg/l is unacceptable for test of water with different concentrations of TDS (www.who.int/water sanitation health /dwq/chemical/tds.pdf, 2014).

2.8.6. Water Temperature

Water temperature could be raised as a result of both natural volcanic activities and industrial discharges. High water temperature enhances the growth of microorganisms and may increase taste, odor, and color problems of drinking water. In analysis of the physico- chemical quality of pipe water samples, temperature is considered as a critical parameter affecting many reactions, including the rate of disinfectant decay and by-product formation. As the water temperature increases, there is increase in the disinfectant demand and by product formation and microbial activity. Corrosion generally increases with temperature as temperature accelerates chemical reactions. Temperature changes the solubility constants and can favor the precipitation of different substances or transform the identities of corrosion products. These changes result in either more or less protection of the pipe surface, depending on the conditions. Temperature also affects the dissolving of $CaCO_3$ which tends to precipitate and form a protective coating more readily at higher temperatures. Temperature can affect the nature of corrosion **(**Wiley, 2005)**.**

2.8.7. Turbidity

Turbidity in water is caused by suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water. Turbidity is measures levels of inorganic and organic solids in water in NephelometricTurbidity units (NTU). Groundwater may contain clay and chalk substances while surface waters may contain various natural or human-induced particulates. Sediments settled in waterways can be disturbed and increase turbidity during heavy precipitation events. Turbidity less than 1 NTU are necessary for effective disinfection, either chemical (chlorine and turbidity levels greater than 5NTU are a clear indication of the presence of solids (potentially harmful) in the water (WHO, 2011).

2.8.8. Electrical Conductivity

EC is a measure of how well water can conduct an electrical current, Conductivity increases with increasing amount and mobility of ions (Selamawit, 2012).

2.9. Bacteriological Water Quality Parameters

The presence of certain microorganisms in water is used as an indicator of possible contamination and an index of water quality. Indicator organisms are selected to demonstrate the presence of human and animal wastes and hence the potential presence of pathogens in drinking water. The presence of indicator organisms in water indicates contamination of water by fecal matter, which could probably contain pathogens; the most common and wide spread health risk associated with drinking water is contamination, either directly or indirectly, by human or animal excreta, and with the micro-organisms contained in faces (Desta, 2009).

Monitoring of specific bacterial and protozoan pathogens is usually complex, expensive, and time consuming, and may fail to detect their presence. In monitoring for microbiological quality, reliance is therefore placed on relatively rapid and simple tests for the presence of indicator organisms in water. There are common organisms used as microbial indicators are total coli forms (TC) and fecal coli forms (FC) (Selamawit, 2012).

2.9.1. Total Coli form

TC bacteria are those that can grow in selective media at 35°C as an indicator of fecal contamination. On the one hand, the Total Coli form group of bacteria is unreliable indicators of fecal contamination because many members are capable of growth and long term persistence (having a non-fecal origin) in many environments, including water distribution systems. There are more TC bacteria in untreated fecal waste than any of the other fecal indicators or indicator groups, making the TC test the most sensitive of all indicator tests. Because of this sensitivity, the TCR (total coli form rule) relies on the TC bacteria test as the initial test to detect the possible presence of fecal contamination in delivered water, as well as to assess water treatment effectiveness and the integrity of the distribution system. the persistence of total coli form bacteria in aquatic systems is comparable to that of some of the waterborne bacterial pathogens (Desta, 2009).

2.9.2. Fecal Coli form

Under the TCR, if the TC test result is positive, that sample is then further tested for the presence of fecal coli form (FC) bacteria. Since it is difficult to monitor disease carrying microorganisms directly we use the count of FC bacteria as a standard measure and indicator of disease potential. The presence of FC bacteria in water indicates that fecal material from living thing or birds is present, so organisms that cause water born diseases may be present as well. The FC group of organisms is a subset of the TC group that can grow in selective media at 44.5°C and ferment lactose, majority of FC bacteria are E. coli (UNICEF, 2011).

2.10. Sample Size Determination for Assessment

Total number of residence in the kebeles was identified; from this total population sample population was determined by using the following statistical formula is used to determine the number of sample size determination for assessment (Cochran WG, 1977)

2.11. WHO and Ethiopian Standards of Drinking Water Quality

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as practicable. Safe drinking water, as defined by the Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages.

In other direction, the nature and form of drinking-water standards may vary among countries and regions and there is no single approach that is universally applicable. Additionally approaches that may work in one country or region will not necessarily transfer to other countries or regions. The aim of drinking-water quality regulations should be to ensure that the consumer has access to sustainable, sufficient and safe drinking-water (WHO, 2011).

Table 2-8 WHO AND ETHIOPIAN GUIDELINES VALUES FOR DRINKING WATER

WHO and Ethiopian guide line values of drinking water	Parameter	WHO standard	Ethiopian standard
1	pH	6.5-8.5	6.5-8.5
2	Turbidity(NTU)	<5 at disinfection point	<5
3	Free chlorine residual(mg/L)	0.2-0.5 at distribution	0.1-0..5
4	Hardness	300mg/L	300mg/L
5	E.C	2000µS/cm	2000µS/cm
6	Temperature	25^{o}c	25^{o}c
7	TDS	1000mg/L	1000mg/L
8	Fecal coli form (CFU/100mL)	0	0
9	Total coli form(CFU/100ml)	-	0

Source http://www.lenntech.com, 2012)

2.12. Water loss

Unaccounted for water (UFW) often constitutes a major problem in water supply, representing considerable loss in revenues, creating excessive production and reducing the available water to customers. According to (Welday,2005), high levels of unaccounted for water indicate inefficiency on the side of a water utility as UFW is a basic measure of the utility's performance.

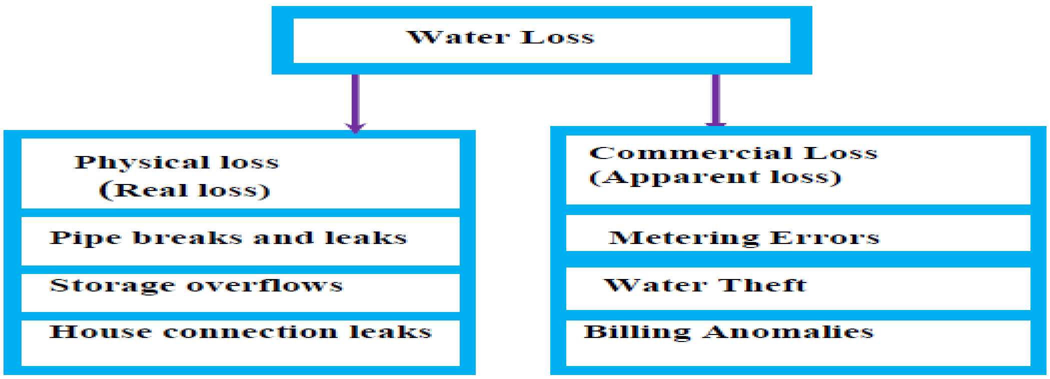
Another factor to be considered to assess the performance of urban water supply systems is amount and causes of water loss. Water losses not only represent economic loss and wastage of a precious scarce resource but also pose public health risks. Every leak is a potential intrusion point for contaminants in case of a drop in network pressures. To recover water losses requires understanding why, where and how much water is lost, and developing appropriate intervention measures (Mutikanga, 2012).

As per Sharma (2008) for Understanding and Managing Losses in Water Distribution Networks the general steps to be followed are: Analysis of network characteristics and operating practices, Quantification water losses and Use of appropriate tools and mechanisms to suggest appropriate solutions. Water loss levels (UFW or NRW) vary widely per country and within one country per city UFW values ranging from 6% to 63% have been reported Water and Wastewater Utility Data – 2nd edition 1996 (Sharma, 2008).

Quantifying and characterizing water loss and leakage in a city water supply is by its nature a complex task. Beside this Leakage identification needs detailed field investigation sometimes using sophisticated equipment. Leakage is often a large source of UFW and is a Result of either lack of maintenance or failure to renewing system and also May caused for poor management of pressure zone, which result in pipe and pipe join failure (Welday, 2005).

2.12.1. Components of water losses

Table 2-9 PERFORMANCE INDICATORS OF WATER LOSSES IN DISTRIBUTION SYSTEM



<table>
<tr><td rowspan="9">System input volume</td><td rowspan="4">Authorized consumption</td><td rowspan="2">Billed Authorized consumption</td><td>Billed Metered Consumption (including Water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water losses</td><td rowspan="2">Apparent losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tank</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer Metering</td></tr>
</table>

Source: (Sharma, 2008)

Unaccounted-for water (UFW) represents the difference between "net production" (the volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not) (Sharma, 2008).

UFW = “net production-consumption-losses”. …………………………...... (2.1)

2.12.2. Non-revenue water

Non-revenue water (NRW) represents the difference between the volumes of water delivered into a network and billed authorized consumption (Sharma, 2008).

NRW = “Net production” – “Revenue water” …………………………………. (2.2)
= UFW + water which is accounted for, but no revenue is collected (unbilled authorized Consumption)

2.12.3. What is an Acceptable Water Loss?

It is a compromise between the cost of reducing water loss and maintenance of distribution system and the cost of the water is saved (Desalegn, 2015).
AWWA Leak detection and Accountability Committee recommended 10% as a benchmark for UFW. Regarding UFW levels and action needed, < 10% Acceptable, monitoring and control, 10-25% Intermediate, could be reduced and > 25% Matter of concern, reduction needed (Sharma, 2008).

2.12.4. Controlling water loss

In order to control water loss methods like leak detection in the field and repair, rehabilitation and replacement program, corrosion control, pressure reduction and public education program Legal provisions such as, water pricing policies encouraging conservation, human resources development and information system development also need to be employed(Desalegn ,2015).

2.12.5. Calculating water loss

Water loss is expressed as a percentage of net water production (delivered to the distribution system), as m3/day/km of water distribution pipe system network (specific water loss) and others like m3/day/connection, m3/day/connection/m pressure and water loss as % of net water production is the most common (Welday, 2005).

2.12.6. Causes of water losses

Leakage is usually the major component of water loss in developed countries, but this is not always the case in developing or partially developed countries, where illegal connections, meter error, or an accounting error are often more significant The other components of total water loss are non-physical losses, e.g. meter under registration, illegal connections and illegal and unknown use .

Unaccounted-for water (UFW) represents the difference between "net production" (the volume of water delivered into a network) and “consumption” (the volume of water that can be accounted for by legitimate consumption, whether metered or not (Melaku, 2015).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Description Of Study Area

Holeta Town administration is found in Oromia Regional State of special Zone of Oromia surrounding Addis Ababa at 29Km to west direction from Addis and 81km from Capital city of west Shewa Ambo to Eastern direction. It located at $9^0$34'27"N and $38^0$29'21''E with an elevation range of 2250 to 2500m above sea level.

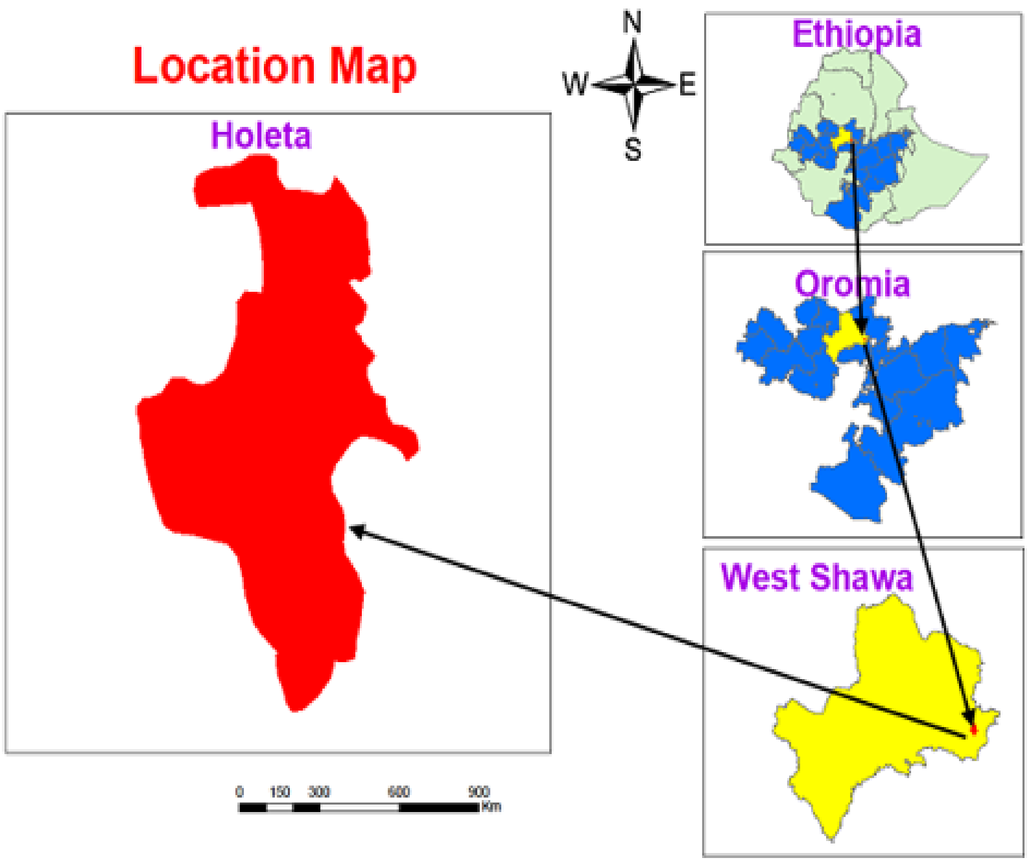


Figure 2 MAP OF THE STUDY AREA

3.1.1. Surface Area, Boundary and Climate

The Holeta town is plain land and bounded by counter side kebele of Welmera woreda as along in northern- Burkussemi, Rob Gabaya & Bosoke Kebele, in the eastern- Menagesha town and 1st and 2nd Berfata Kebele, in western-Ejere woreda, in south- Welmera Zone.

The survey will be conducted in Eight kebeles of Holeta town Goro Qeransa, Birbirsa Siba, Tulu Harbu, Burqa Harbu, Mada Gudina, Galgal Kuyu, Burka Walmara and Sadamo.

In a newly – Engineered boundary, the Holeta town surface area sources about 55.89 km^2 (5500 hector) which is the biggest town in Welmera woreda. Annual rainfall is 1040-1100ml on average (Holeta urban planning office, 2009).

3.1.2. Topography of the Area

It consists of 8 kebeles central highlands having a sloppy to gentle geography with slight variation in elevation. The town is located on plain land at all other than few query areas and hectares in the southern part of the town, hence, woinedega / temperate / more or less characterizes the town`s administration (Holeta urban planning office, 2009).

3.1.3. Climate

According to the meteorological data, the annual mean temperature is on average 14℃ with the hottest month may and with mean highest temperature 23.8 ℃ on average and December is the coldest month with an average lowest temperature 1.7℃ the annual mean rainfall is 1060 mm with an average relative humidity of 58% consequently (Holeta urban planning office, 2009).

3.2. Materials and Tools

Based on the research objectives and questions in the introduction the materials of the research are presented here. The methods of data collection and data preparation are also discussed.

- The existing Water distribution Network of Holeta town.
- Arc.GIS
- Water GEMSV8i.
- GPS
- Pipe diameter and type of pipe
- Incubator with all accessories
- Water sample collected from source of water, tap and storage
- Digital Titerator
- Turbidity meter
- PH/Conductivity/TDS/Temp. Meter
- Chronoscope(comparator)
- Data Collected from Water supply office of Holeta.

3.3. Flow Chart of the Thesis

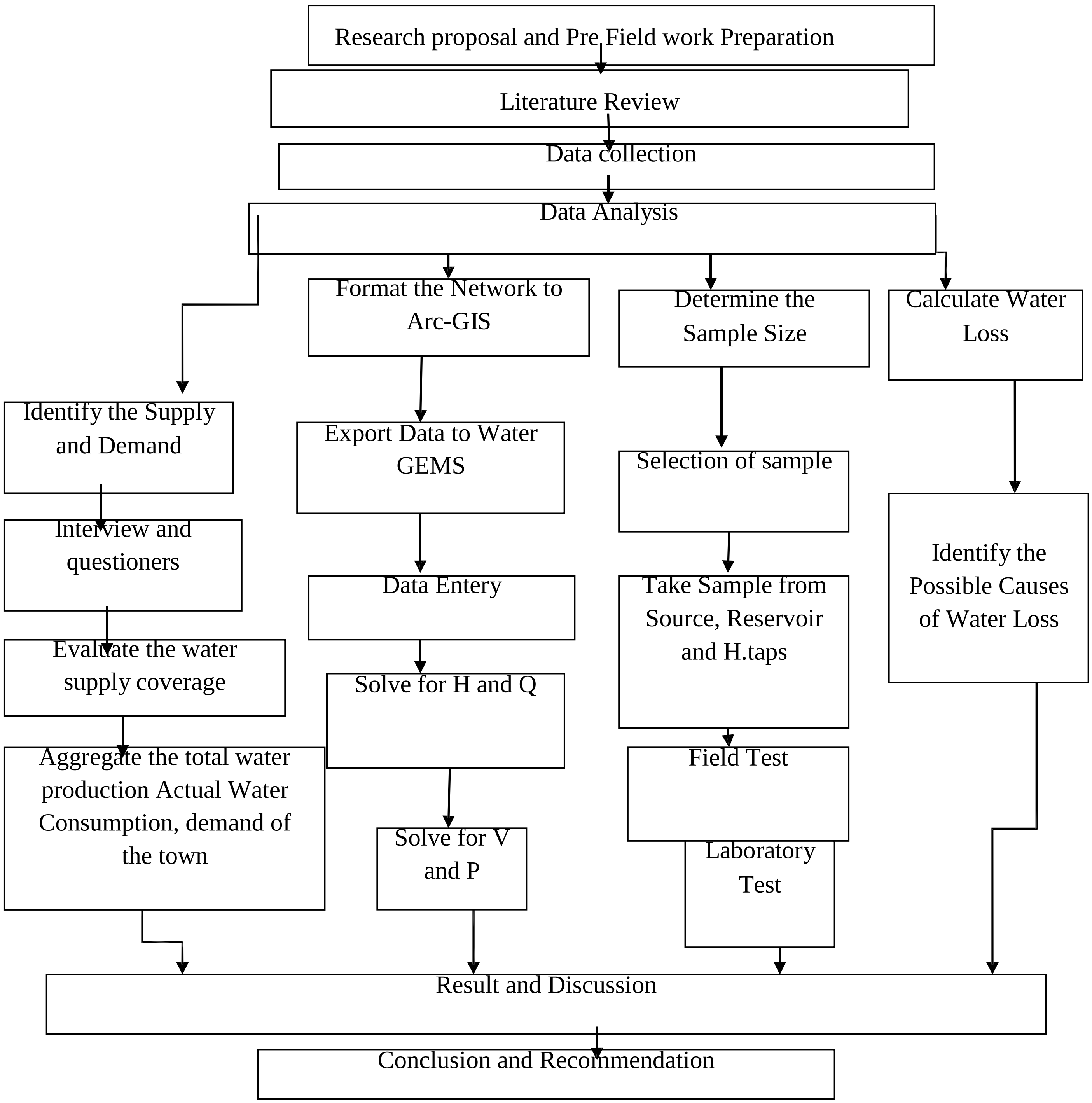


Figure 3 GENERAL FRAME WORK OF THE THESIS

3.4. Population forecasting

Population projection (forecasting) provides information on the future size, composition of a given area. Knowledge of this information is fundamental for development plans where target is to satisfy the future need of population in the area of water demand. The basic components change in the size and composition of population of certain area includes fertility, mortality and migration.

Different population forecasting methods are in fact available and can be used for population Projection. But their result varies from one method to another. Preference of the method appropriate for particular town needs to consider overall current situations of the targeted town. for fast growing town, where relatively high economic activity is observed and at the same time continuous expansion of town due to various reasons is experienced, exponential method population forecasting is preferably used.

The 2014 Census undertaken by the Central Statistical Agency (CSA) gave the population of Holeta town as 40,528 in 2016. Hence, the population of Holeta is expected to show a medium growth rate. Accordingly for the projection of the population, the medium growth rate was used. Exponential population forecasting method is expressed as follows;

$$Pt = Po * e^{rt} \quad \ldots\ldots (3.1)$$

Where Pt = is projected population at time t

Po = i s initial population at time o

e=constant e, the base of natural logarithm

r=is annual growth rate

t=number of years

3.5. Water Demand

The design and execution of any water supply scheme requires an estimate of the total amount of water required by community. The total amount of water demand is affected by the expected development of the city, presence of industries, quality of water and its cost, characteristics of the population and efficiency of the water work administration. Generally, in designing the water supply scheme for a town or city, it is necessary to determine the total quantity of water required for various purposes. the water demand of Holeta town has the following categories: Domestic demand, small scale industrial demand and institutional and commercial demand.

The demand for various purposes is divided under the following categories: - domestic water demand, Institutional water demand, Non-domestic water demand, Commercial water demand and Industrial water demand. The water demand for actual household activity is known as domestic water demand. It includes water for drinking, cooking, bathing, washing, flushing, toilet, etc. The demand will depend on many factors, the most important of which are economic, social and climatic factors.

Water supply for population is served by the mode of service which is prevalent to most Ethiopian towns used to be classified in to four major categories as follows: - House tap users (HTU), public tap private, public tap shared and Public tap users (PTU). The water demand is calculated for the domestic water demand, per capita domestic water demand, non-domestic water demand, and institutional water demand, commercial water demand ,Industrial water demand, commercial water demand, Total Average Daily water demand (total sum of domestic ,non domestic and an accounted for water demand), Maximum Daily Water Demand (ratio of maximum daily consumption to Average daily consumption, There is no recorded data for the maximum day factor for many Ethiopian towns. However, a factor ranging from
1.2 to 1.5 is used in several of our towns) and Peak Hour Demand.

The annual consumption data was converted to average daily per capita consumption using the number of population.

3.6. Water supply coverage

The percentages of population with or without piped water connection are a relevant indictor to compare the coverage of water supply in urban areas.

Water supply coverage is usually evaluated based on the quality, quantity of the supply and level of connection that is related to the water supply. In this part of the analysis, the number of domestic connection per family and the average daily per capital consumption is used to analysis the domestic water supply coverage for the city.

3.6.1. Domestic water supply coverage

The water supply coverage of the city has been evaluated based on the average per capital consumption and level of connection per family. The average per capital consumption has been derived from the yearly consumption of each kebeles that has been aggregated from the individual domestic water meters. Beside to the average per capital water consumption, the distribution number of domestic's connection per family has been also evaluated. Statistical analysis was used to evaluate the supply coverage for the city and supply coverage map has been prepared for the city. Number of population as forecasted to the year has been used to evaluate the average per capital consumption (Asmelash, 2014).

$$Per\ Capita\ consumption\left(\frac{\frac{L}{c}}{day}\right) = \frac{Annual\ Cons.(m^3)*1000l/m^3}{Pop'nNumber*365days} \dots\dots\dots\dots\dots\dots\dots\dots..(3.2)$$

The total numbers of connection or water meter within the city are about 6791. that the level of water connection is important element to know the level of water supply coverage and total number of connection or water meter is must needed, according to central statically agency and world bank survey report, 2013 average family size there are regional difference, Oromia and SNNP region have highest average house hold size with 5.5 person per house hold. So the level of connection per family is determined as

$$connection\ per\ family = \frac{Total\ number\ of\ connection\ of\ kebele}{(Number\ of\ pop'nb\ by \frac{kebele}{Aerge} family\ siz)} \quad \text{.........................} \quad (3.3)$$

3.6.2. Water Supply Coverage Analysis

The water supply coverage of the town was evaluated based on the average per capita consumption and by mode of service. The average per capita consumption was derived from the yearly consumption that will be aggregated from the individual domestic water meters.

Beside to the average per capita water consumption, the distribution of number of domestic mode of service will be also evaluated. Statistical analysis was used to evaluate the supply coverage for the entire town. as (Desalegn, 2015), Water supply coverage is calculated using the formula:-

$$Water\ Supply\ Coverage = \frac{Annual\ Production * 100\%}{Annual\ Demand} \quad \text{.......................... ....} \quad (3.4)$$

3.7.Sample Size Determination Method

Samples were taken from locations that were representative of the water distribution Systems and household connections. Total number of residence in the eight kebele was 15,784 (Holeta, 2017); from this total population sample population was determined by using the following statistical formula (Cochran WG, 1977).

$$ni = \frac{N * Z^2 * P * Q}{W^2 * (N-1) + Z^2 * P * Q} \quad \text{..} \quad (3.5)$$

Where

n (i) ……………….sample household

N…………………...total number of house hold

P…………………….proportion (50%)

Q…………………….1-P

Z………………………..95%confidence interval

(1.96)

W…………………………5%

$$ni = \frac{15{,}784 * 1.96^2 * 0.5 * 0.5}{0.05^2 * (15{,}784 - 1) + 1.95^2 * 0.5 * 0.5} = 380\ House\ hold$$

3.8. Sample Selection for Customer Satisfaction Analysis

For Customer Satisfaction Analysis 380 sample size was used to fill the questionnaires ,interview in order to know the customers satisfaction, to assess the customers' opinions regarding the water supply service of Holeta town by systematic random sampling method all kebeles. Questionnaires were used to collect primary data from customers with respect to their response regarding the quality, quantity, continuity of water, monthly tariff and interviews were used to collect primary data from the officials. The secondary data was collected through. Water resources performance, Pressure complaints, Water resources availability, Residential customer connection efficiency and Water quality complaints.

3.8.1. Data collection methods

The primary and secondary data was collected from the town water supply service and at the land in situ (field) testing was carried out. Some supplementary information was also collected from other respective offices, supportive qualitative information through discussion with local experts of water supply service through Site Visit, structural questionnaires.

3.9. Hydraulic Performance Analysis of the Distribution System

3.9.1. Distribution System Analysis

Water GEMS V8i was used for the purpose of understanding pressure regime, demand, velocity, and head loss and overall systematically studding and better understand network operation. Hydraulic performance analysis was carried out for extended period using Water GEMS. GIS location Map showing the town water sources, reservoirs and boost stations is produced by taking GPS readings of the existing water sources, reservoirs and pumping stations. The analysis is beginning by feeding the diameter of distribution pipes in to software and the pressure, velocity and head loss are in the distribution system. By using the land use map, the area that was supplied for each node is marked, measured, and tabulated under each category. The total water demand for each category is computed. The demand area ratio for each category is computed assuming the population distribution is uniform.

3.9.2. Hydraulic design

Applying Hazen William formulas' that is used for flow computation.

$$V = 0.85C * R^{0.63} * S^{0.54} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.6)$$

Where V = flow of velocity in (m/sec)

C = Coefficient of hydraulic capacity

R = Hydraulic mean depth in (m)

By substituting and re-arranging

$$S = \frac{HL}{L} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3.7)$$

$$HL = L * (0.00212D - 4.87Q^{1.85} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3.8)$$

Where HL =head Loss in (m) L = Length of pipe in (m)

D = diameter of pipe in (m)

Q = Discharge (flow through the pipe) m^3/sec

Empirical formula for determination of economic pipe diameter is: -

$D = 1.22\sqrt{Q}$ ………………………………………………………………… (3.9)

Where D = Economical Pipe Diameter in (m)

Q= Flow through the pipe (m3/sec)

Note. Velocity through the pipe ranges b/n 0.5 to 2.5 m/sec (Amdework, 2012).

3.9.3. Calibrating Hydraulic Network

Ten representative samples have taken; according to (USEPA, calibration Guidelines) http;//www.awwa.org/unitds/592/calibrate.pdf,accessed December 2008. measurements to the water main spread throughout the study area have been selected for the calibration.

It was difficult to take measurement at a direct connection to the water main nodes, due to size of pressure gauge available in Holeta, which is 25mm.

Field test locations for this exercise are identified through a process known as the sampling design problem which essentially defines the limiting calibration criteria that delineate the test location sample space .Test location sampling is done randomly and the following limiting criteria often used (AWWA, 1999).

1. Sampling points should be at the extremities of the network, a considerable distance from the boundary nodes in the network (reservoirs and tanks).
2. Selected points should also have relatively high discharges and pressures.
3. The actual values of the minimum distance from boundary nodes, minimum discharge, and minimum pressure are relative and unique to a given model. They are therefore selected having considered the system hydraulics and constraints of the modeling environment (Walski, 2003).

3.9.4. Pressure Measurement

Pressures are measured throughout the water distribution system to monitor the level of service and to collect data for use in calibration. Pressure readings are commonly taken at water distribution mains also at hose bibs, and home faucets (Bentley, 2008).

3.9.5. Performance Evaluation

In order to calibrate and validate the hydraulic network and for comparison purposes, some quantitative information is required to measure model performance. In this study, the pressure data measured at the near to node home faucet of the system was used to assess the model performance. The performance assessment was based on the water measured and simulated data, the agreement of the overall the time series of pressure the value of the statistical performance indices (Walski, 2003). Such as the degree of accuracy (error of difference) and the goodness of fit tests (R2) are two techniques to be considered for calibration model test as mentioned below.

1. Measure of goodness-of-fit of linear regression

Coefficient of determination (R2): The meaning of R2, the value R2 is a fraction between 0.0 and 1.0, and has no units. If R2 value of 0.0 means that knowing X does not help you predict Y. There is no linear relationship between X and Y, and the best-fit line is a horizontal line going through the mean of all Y values. When R2 equals 1.0, all points lie exactly on a straight line with no scatter. Knowing X lets you predict Y perfectly Coefficient of determination (R2) describes the degree of co linearity between simulated and measured data. The coefficient of determination, R2, Equation (4.1), which ranges between 0 and 1, describes the proportion of the variance in the measured data, which is explained by the model, with higher values indicating less error variance. Typically, R2 > 0.5 is considered acceptable (Bentley, 2008).

$$R^2 = \left[\frac{\sum_{i=1}^{n}(O_i-\bar{O})(P_i-\bar{P})}{\sqrt{\sum_{i=1}^{n}(O_i-\bar{O})^2}\sqrt{\sum_{i=1}^{n}(P_i-\bar{P})^2}}\right] \quad , 0\leq R^2 \leq 1 \qquad \text{.....................} (3.10)$$

Where,

n- the number of observations in the period under consideration

Oi-, the i-th observed value

Õ, - the mean observed value

Pi, - the i-th model-predicted value and p, -the mean model-predicted value (Bentley, 2008).

3.10. Water Quality

Water quality assessment in conjunction with improved sanitation practices is important to ensure that the particular practices implemented significantly decrease water supply contamination so in order to collect the data for water quality were taken the primary data from the source, on distribution line and at the tap.

3.10.1. Water quality analysis

The data were collected from the source, the distribution line and from the taps depending on the size of the sampling. A sample of water from the borehole shall be taken at the end of constant rate test for physic- chemical and bacteriological test.

3.10.2. Sample size Selection for Water Quality Analysis

Samples were taken from locations that were representative of the water distribution systems and household connections. Random sampling method was used to determine representative sampling points for water quality analysis from a total sample 5% was taken as a representative sample. As the basic assumption that Water quality may not vary at a nearby distance. Total population sample population was determined by using the following statistical formula (CochranWG, 1977).

$$ni = \frac{N * Z^2 * P * Q}{W^2 * (N-1) + Z^2 * P * Q} \quad \ldots\ldots (3.11)$$

$$ni = \frac{15{,}784 * 1.96^2 * 0.5 * 0.5}{0.05^2 * (15{,}784 - 1) + 1.95^2 * 0.5 * 0.5}$$

Ni= 380HH .For water quality analysis from a total sample 5% was taken as a representative sample. As the basic assumption that Water quality may not vary at a nearby distance.

Sample size =5%*380=19 Sample

Table 3-1 DATA CATEGORIES FOR SAMPLE POINT

Type of Sample	Quantity	Remark
Private Costumers water Taps	19	Represented By HHT-1to HHT-19
Source	9	Represented By S-1 to S-9
Reservoirs	3	Represented By R-1 to R-4
Total sample	31 total number including the source and reservoir	

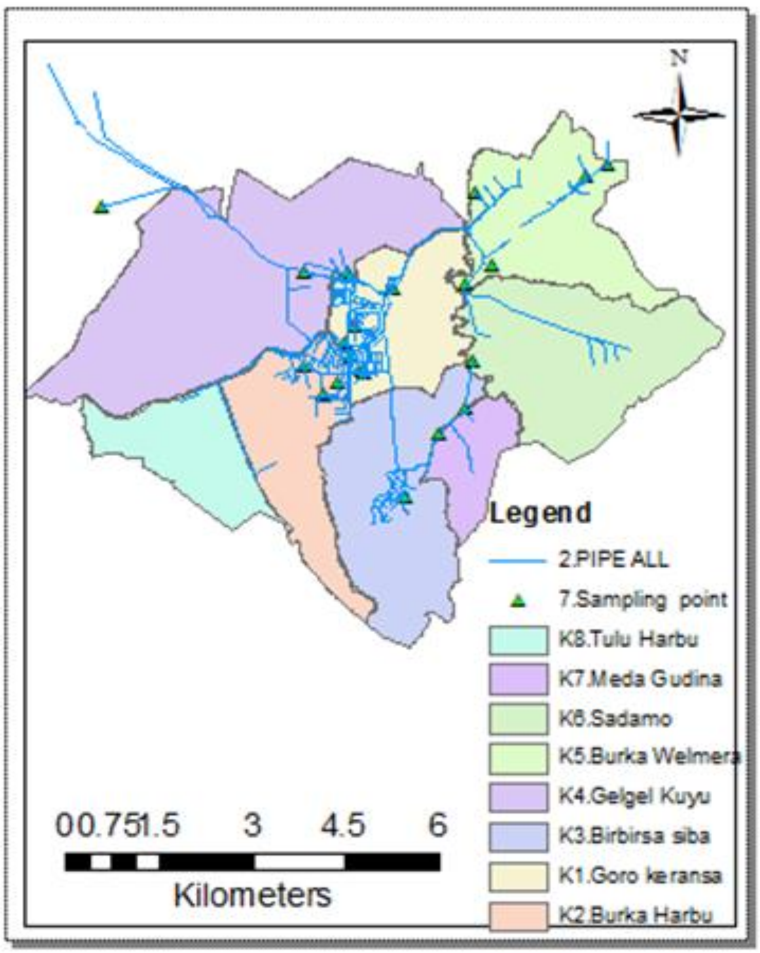


Figure 4 SAMPLING POINT

3.11. Physico-chemical & bacteriological test at spot and Laboratory.

Water sampling and analysis has been conducted on Holeta Town Water Supply & Sewerage Enterprise. To conduct water quality test (water sampling and analysis) has been conducted on different sampling point. Water samples have been collected from different sampling point for on-site analysis (bacteriological). The onsite analyzed parameters were pH, Temperature, TDS, EC, In addition to the onsite analyzed parameters Hardness, Residual chlorine, E-coli (Faecal coli form) and Total coli forms. , the samples have been collected, well-preserved and transported to Addis Ababa, Oromia W. M. E. Bureau, and Water Quality Control Laboratory for the remaining physico-chemical analysis.

3.11.1. PH/Toc/TDS/EC Meter –PH method

Water samples were collected in properly washed and rinsed plastic bottles. PH, Temperature, Total Dissolved solid (TDS) and Electrical Conductivity (EC) were measured on the spot by HQ440d multi pH/T°C/ TDS/EC meter having the respective electrodes. the above parameter were determined by apparatus PH meter by the following steps: - Wash the electrodes carefully with distilled water, Immerse the electrodes into the sample of water (whose pH is to be determined) and wait up to one minute for steady reading, at the end the measured parameters were displayed in PH meter, reading is observed after the indicated value becomes constant.

3.11.2. Titration method for Total hardness

In the total hardness test procedure, the water sample is first buffered (using an organic amine and one of its salts) to an organic dye, calmagite, is added as the indicator for the test. The organic dye reacts with calcium and magnesium ions to give a red-colored complex. EDTA (ethylenediaminetetra acetic acid) was added as a titrant. The EDTA reacts with all free calcium and magnesium, in the sample. At the endpoint of the titration, when free magnesium ions are no longer available, EDTA removes magnesium ions from the indicator. The indicator then changes from red to blue the analyst red the end point of color change.

3.11.3. Turbidity –turbidity meter method

Measure the turbidity by apparatus Turbidity meter with following the steps collecting sample from the source, Reservoir and water taps directly by Take 25ml of filtered sample in a flask, Adjust the Turbidity meter by selecting from the spectrometer list for turbidity, put the samples to the Turbidity meter and then press start finally Take the reading from the screen.

3.11.4. Residual chlorine measurement - DPD method

Free residual chlorine was measured using a simple chlorine comparator or Chronoscope having color disks of various intensities. DPD (Diethyl Phenyl Damien) reagent was added in 10 ml of sample so that color developed in proportion to the amount of free chlorine present in the water in testing method. Then its color was compared against pre prepared color disks having different intensities corresponding to different concentrations of free chlorine (0.1-5mg/l); if color produced that time compare it with water in other tube and record result.

3.12. Microbiological examination procedure for Total Coli forms and fecal coli forms

3.12.1. The membrane filtration technique method

Each and every materials or equipment sterilized by flam, autoclave or by boiling. Sample collected by pre-sterilized sampling bags using dispenser put absorbent pad in to the Petri dish. Pour the appropriate medium to it, close, label, and put it aside on a tray. Take sample with your sterile sampling cup. Assemble the filtration unit. Take filter using a sterile forceps, put it grip side up on the filter holder. Shake the sample and pour it in to the funnel to 100 ml mark. Apply vacuums to filter the sample. Tightly Put Petri dish in an incubator upside down at 350c and 370c (for a total coli form) or at 44.50c + 0.2 (for fecal coli form) Check dishes for reproduction of coli forms after 18-24 hour Report result of counting as X number of colonies per 100 ml or TNTC -Too Numerous to Count (>
300 colonies /100ml), it is supposed that fecal and total coli forms must not be found at all drinking water (WHO and Ethiopian Guideline).

Besides water samples are taken from sources, reservoirs, and from house connection and water quality analysis was done for different water quality parameters such as turbidity, coli form, residual chlorine, hardness, PH and the results is compared against international and national guidelines and based on the result recommendation is given to improve the water quality.

3.13. Water loss

In order to control water loss methods like meter testing and repair/replacement, improving billing procedure, Leak detection and control program, network evaluation, leak detection in the field and repair, rehabilitation and replacement program, corrosion control, pressure reduction and public education program need to be implemented.

3.13.1. Water loss analysis

The total annual water produced and distributed to the distribution system and the water billed that was aggregated from the individual customer meter readings were used to quantify the total water loss for the town. The water production and consumption of the water supply service are assessed based
the past five year's record. The total water produced and the actual water consumption as aggregated from the individual contracts (customer meters) was used as an input for the water loss analysis. Water meter accuracy test was conducted and the result was used as an input in the analysis of the total water loss components.

The number and type of customers with their corresponding meter type was collected from the Holeta water supply office that can be used in the determination of water loss. in this research paper the water loss is calculated from the water production and consumption Data of previous years.
as (Sharma, 2008) the total water loss is calculated as:-

$$Total\ Water\ Loss\% = \frac{Total\ Produced - Total\ Billed}{Total\ produced} * 100\% \quad \text{……………………} (3.12)$$

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Existing Water Supply System

The source of water supply for the Holeta town is groundwater. In 2017 from ten boreholes only nine of them are giving service and current yield of these wells is 1,307m^3/day. The total length of distribution pipelines installed by the town WSS was 108.34Kilometer up to date. Currently, the population of the town is more than 63,139 (Appendix-3, Table 3-2). This shows that there is a shortage of supply of drinking water, particularly, in Holeta. Relating to tariff of the existing (Appendix- 4 ,Table 4-2) and current (Appendix 4-Table.4-3) .water tariff of Holeta town is a four-band and five band system tariff respectively .beside this the result concerning to the water supply system There are problem of Interruption of electric power, absence of generator, Lack of timely maintenance of pipe line, The capacity of water source is not enough to the town population, Shortage of private water meter, Less commitment of the office to solve the problem, good governance problem and water quality problem .

Table 4-1 SOURCE WATER SUPPLY IN HOLETA TOWN WITH ITS DISCHARGE

No.	source	Con.Year Start function	Place	Depth(m)	Discharge(L/s)	Destination To	Remark
1	BH-1	1997	Walmara	90	3	R-3	functional
2	BH-2	2004	Walmara	147.5	4	R-3	functional
3	BH-3	2005	M.Gudina	330	5	R-2	functional
4	BH-4	2007	Walmara	90	3	R-1	functional
5	BH-5	2009	Dobi	335	10	R-1	functional
6	BH-6	2006	B.Gudina	210	3	R-2	Not. function

7	BH-7	2012	Dhamotu	300	12	R-1	functional
8	BH-8	2012	Dhamotu	320	7	R-1	functional
9	BH-9	2012	Dhamotu	300	4.5	R-3	functional
10	BH-10	2013	Dhamotu	310	8	R-4	functional

The existing water supply highest percentage is Galvanized iron pipe from the study almost 75 % is more than 15years this indicate the system is must renewed and again it need detial design for the town.

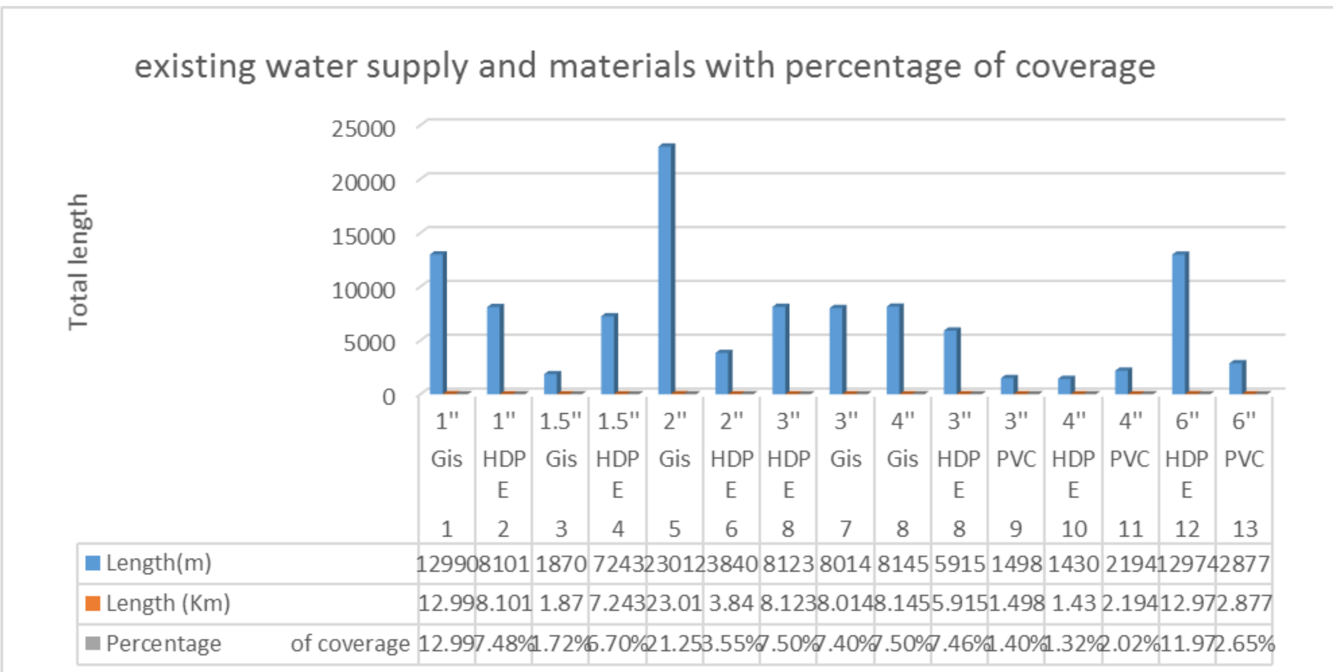


Figure 5 EXISTING WATER SUPPLY

4.1.1. Town Water Reservoirs

The water reservoirs were collected in conjunction with the main water network on the town. There are four concrete reservoirs in the distribution system located at three places. The two circular concrete reservoirs are located in Gelgel kuyu is and the other two is in welmera kebele, this shows that the reservoir from Gelgel kuyu is total capacity 1,100m^3 ·beside this other two is only with the capacity of 125m^3 this shows that the system of supply is not inter connected and the problem of deficit is seen in welmera and sedamo kebele.

Table 4-2 CURRENT RESERVOIRS USED FOR HOLETA WATER SUPPLY SYSTEM

No.	water reservoir	Shape of reservoir	When it start functionality	Capacity	Remark
1.	GKR-2	Circular	2001	300 m^3	functional
2.	GQR	Circular	2003	75 m^3	b/c of line problem not functional currently
3.	BWR	Circular	2010	50 m^3	functional
4.	GKR-1	Circular	2015	800 m^3	‘’

4.1.2. Water demand and supply of the town

The total capacity of water supplied by Holeta town water supply scheme are 1,307m^3/day but daily water demand is calculated by using mode of service ,population growth rate of the Town the result shows that the demand of the town is 2,485m^3/day. Per capita in 2017 (Appendix-4).This shows that the water supply produced and demand is not balanced, this is because of the capacity of the source of the town is not enough; interruption of electric power and lack of timely maintenance of the pipe line is seen suddenly.

As the results shows that total capacity of water supplied by Holeta town water supply scheme are 1,307m^3/day but daily water demand of the Town Per capita this shows that the water supply produced and demand is not balanced, this is because of the Capacity of the source of the town is not enough in order to satisfy the demand of customers.

4.1.3. Water production

As it is indicated on the existing water supply system section of this research the existing water supply for Holeta town is obtained from ten boreholes and located at the border of the town (Appendix- 5) The current Water Resource and Supply system has 10 deep well, 51 public taps and four reservoirs with capacity of producing water 1,307m^3/year, main supply system which contain 108.3km with water supply coverage 52.57% with numbers of customers 6,791.

Table 4-3 ANNUALY WATER PRODUCTION FROM EXISTING SOURCES (2012 TO 2017).

Year	2012	2013	2014	2015	2016	2017
Total Pop'n	33,942	35,372	37,071	38,715	40,528	63,139
Water production(m3)	269,740	205,201	197,632	254,889	276,752	476,752

4.1.4. Water Consumption

In order to evaluate the water loss in the distribution system, consumption data of each customer were collected from the computer information section of WSS. There are more than 6,791 numbers of customers within the entire to (Appendix -6)

Table 4-4 ANNUALY WATER CUNSUMPTION FROM EXISTING SOURCES (2012 TO 2017).

Year	2012	2013	2014	2015	2016	2017
Total Pop'n	33,942	35,372	37,071	38,715	40,528	63,139
Water Consumption(m3)	224,225	170,317	165,835	206,450	237,080	415,493

4.2. Water supply coverage

The water supply coverage of the town was evaluated based on the average per capita consumption and level of connection per family.

The actual water supply coverage in cities of developing countries is very low while compared to the demand. The average domestic water supply coverage of the town is found to be 20.68 l/capital/day.

This average per capita consumption is very low while compared with the country standard used for design purpose (30 to 50l/capital/day) and even it is lower than that of the minimum standard set by

UN-Habitat as a basic need 20l/capital/days in 2017

Beside to the overall low supply coverage, supply disparity existing among different localities. Therefore evaluating the city distribution of the water supply is important in order to identify the problematic areas and intervene accordingly. In this part the number of domestic connection per family and the average daily per capital consumption is used to know the domestic water supply coverage for the city. Beside annual water production (Table 4-3). The annual demand of the town population shows that the water supply coverage of Holeta town is very low.

4.2.1. Domestic water supply coverage

The water supply coverage of the city has been evaluated based on the average per capital consumption and level of connection per family. The average per capital consumption has been derived from the yearly consumption of each kebeles that has been aggregated from the individual domestic water meters. Beside to the average per capital water consumption, the distribution number of domestic's connection per family has been also evaluated. Number of population as forecasted to the year 2017, has been used to evaluate the average per capital consumption.

The total numbers of connection or water meter within the city are about 6791. That the level of water connection is important element to know the level of water supply coverage and total number of connection or water meter was evaluated.

Table 4-5 LEVEL OF CONNECTION PER FAMILY

Year	Total population	Average family size	Total number of connection	Level of connection
2012	33,942	5.5	3,466	53.86
2013	35,372	5.5	4,106	47.38
2014	37,071	5.5	4,769	42.75
2015	38,715	5.5	5,378	39.59
2016	40,528	5.5	5,893	37.83
2017	63,139	5.5	6,791	51.14

4.3. Water Demand and Consumption

Demand of water for Holeta town is greater than the amount supplied rather than the actual consumption. Generally the water supply and demand is not balanced with the amount of actual supplied.

Table 4-6 CALCULATED WATER DEMAND

Year	2015	2016	2017	2022	2027	2032
Projected population	38,715	40,528	63,139	89,599	127,146	180,429
TDD (m^3/d)	607.8	716.3	1507.8	2192.5	3183.7	5314.6
NDD (m3/d)	182.3	214.9	452.3	657.7	955.1	1594.4
UWD (m3/d)	215.7	253.3	524.5	757.0	1091.0	1807.4
TWD (m3/d)	1005.9	1184.5	2484.6	3607.3	5229.9	8716.4
Socio-economic factor	1	1	1	1	1	1
Climatic Factor	1	1	1	1	1	1

Ave.TD (m3/d)	1005.9	1184.5	2484.6	3607.3	5229.9	8716.4
Ave. TD (l/day)	1005880.7	1184527.3	2484606.4	3607255.9	5229859.2	8716412.5
MDF	1.3	1.3	1.3	1.3	1.3	1.3
MDD (m3/d)	1307.6	1539.9	3230.0	4689.4	6798.8	11331.3
MDD (l/day)	1307644.9	1539885.4	3229988.4	4689432.6	6798816.9	11331336.2
MDD (l/sec)	15.1	17.8	37.4	54.3	78.7	131.1
PHF	1.8	1.8	1.8	1.8	1.8	1.9
PHD (m3/d)	1810.6	2132.1	4472.3	6493.1	9413.7	16561.2
PHD (l/day)	1810585.2	2132149.1	4472291.6	6493060.6	9413746.5	16561183.7
Demand l/person/day	47	53	71	72.5	74	92

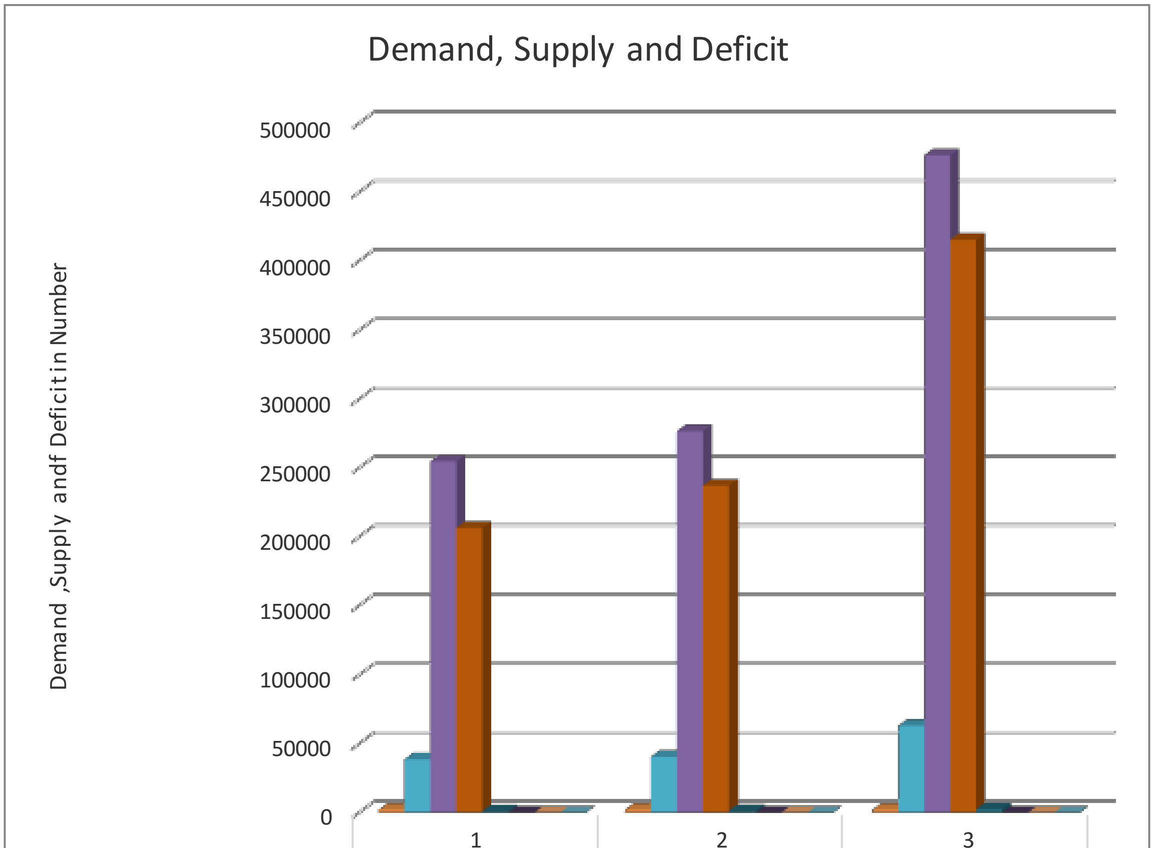
The water supply coverage is very low when compare with its production and consumption which shows that 52.57 % only.

Table 4-7LEVEL OF WATER SUPPLY COVERAGE DEMAND AND CONSUMPTION OF HOLETA IN 2017

Year	Total Pop'n	Annual Water pro.(m3)	Annual Water cons.(m3)	Demand			Production	consumption	Percentage of coverage
				TWD m3/day	Total Demand L/day	l/P/day	Total production m3/day	l/P/day	
2017	63,139	476,752	415,493	2,484.6	4,472,291.6	71	1,307	20.68	52.57

4.3.1. Average Daily Per Capita Consumption

The level of water consumed for domestic purpose has been aggregated to town so as to analysis the distribution of the water coverage among different localities. the level of water consumed for domestic purpose has been aggregated to all kebeles so as to analysis the distribution of the water coverage among different localities. For this reason the annual consumption data has been converted to average daily per capital consumption using the number of population and the result shows that the demand 71/p/day with water supply only 20.68l/p/day with high deficit of water 50 l/p/day, this shows the shortage of water supply are seen when compare to the demand of the town.



	1	2	3
Year	2015	2016	2017
Total population	38715	40528	63139
Total pro.(m3)	254889	276752	476752
Total cons.(m3)	206450	237080	415493
Total demand m3/day	1005.9	1184.5	2484.6
Demand l/person/day	47	53	71
consumption l/person/day	18.03760887	18.7086621	20.68721176
Water deficit l/person/day	29	34	50

Figure 6 DEMAND OF THE TOWN

the distribution of average domestic water supply coverage of the Town in the year 2017, is found to be 20.68 l/capital/day which are far from demand of the Town. this average per capita consumption is very low while compared with the other country standard.

4.4. Customer Satisfaction

It is the very nature of this commodity that makes the customer satisfaction so important. Water is a lifeline whose importance is felt only when people cannot get enough of it. It is keeping this in mind that urban water distribution networks are designed to supply water for household customers as well as industrial concerns 24 hours a day, 365 days of the year. Any disruption or inconsistency in this service even though for a short while has an unpleasant effect on all sorts of customers. The research was exploratory as it seeks to find out whether the customers are satisfied or not with the clean drinking water provided. The collect information about customers' satisfaction towards the water supply service (Appendix -7).

There are a total number of 6791 customers including residential, institutional, commercial and industrial customers. The number of residential house customers estimated up to 94.5% from the total customers. Water supply coverage is not sufficient.

The customers are not satisfied by water supply system in term of water quality, maintenance and the office is not respond the casters question at required time as get the result from customers interview and questionnaires(Appendix -2 list of questionnaires).

Out of the total 380 respondents asked for water supply office respond earlier for your question on maintenance, 198 or 52% said that yes while 98 or 25% said no they are not satisfied.

Out of the total 380 respondents asked for daily water consumption, 129 or 34% said that they use less than 50litre per day and 38 or 10% said that they use 51-100 liter per day and 50 or 13% said that they use 101-500 liter per day and 4 or 1% said that they use greater than 500litre per day.

Out of the total 380 respondents asked for sufficient pressure on their household taps, 208 or 54.67%

Said that they get sufficient pressure at their taps while 39 or 8.67% said the pressure is not enough.
Out of the total380 respondents asked for satisfaction on the clean water 232or 61% said that they are satisfied with the clean water and 8 or 2.1% said that they are not satisfied with the clean water while 22 or 5.78% said that the quality depends on the season.

Out of the total 380 respondents asked on home water treatment method 209 or 55 % said that they have no any water treatment method at home.

Out of the total 380 respondents asked on water tariff, 4 or 1.05 % said that the current water tariff is affordable while 299 or 78.7 % said that the current water tariff is not affordable.

Out of the total 380 respondents asked for functionality of their water meter, 236 or 62% said that their water meter is functional.

Out of the total 380 respondents asked for availability of water per day, 50 or 13% said that water available less than 6 hours per day and 106 or 28% said that water available for 7-12 hours per day and 4 or 1% said that water is available for 13-18 hours per day and 2or 1% said that water is available more than 19 hours per day as and the result shows that the customers are not satisfied in terms of water supply coverage and water quality.

Out of the 380 respondent almost 85% is respond for the questionnaire and they are not satisfied with the water supply service.

Table 4-8 EXAMPLE OF RESPONDANT

No.	customers interviewed	Total customers	Does the water supply office respond earlier for your question on maintenance?			
			yes	No	Miss	Percentage of respond
1.	private residence	250	110	90	50	80%
2	Institutional	10	1	4	5	50%
3.	Commercial	115	85	3	27	76.52%
4.	Industrial	5	2	1	2	60%

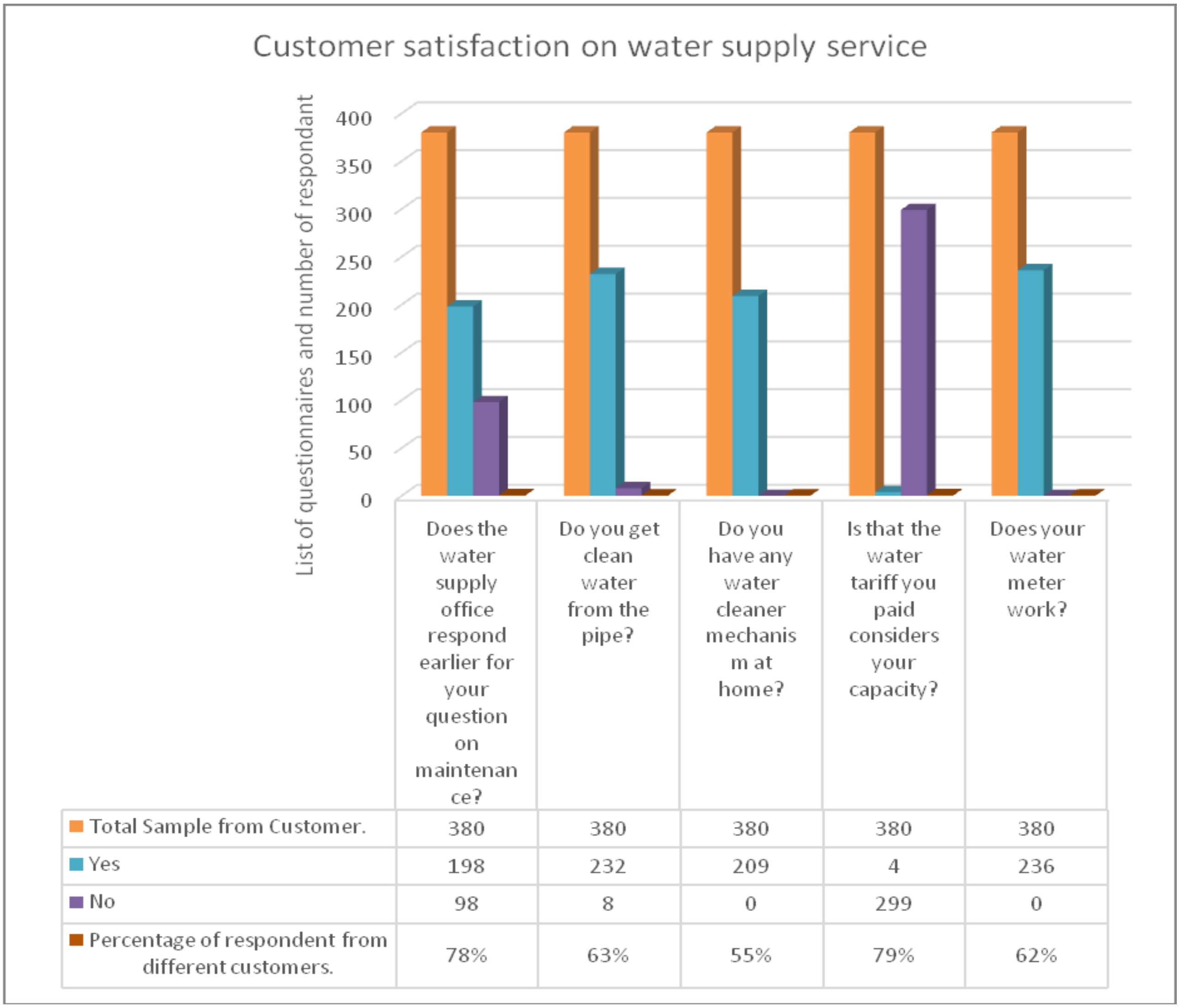


Figure 7 CUSTOMER SATISFACTION

4.5.Hydraulic performance result Water supply system

Water distribution systems include pumping stations, distribution storage and distribution Piping. The hydraulic performance was in terms of the pressure it is 42% is out above 70m head.

The specified requirements in terms of Velocity the result shows that the Velocity in percentage less than 0.5m/s is 72% and greater than 2.5m/s is 2%.

4.5.1. Pressure and velocity in the system

The frictional head losses in the distribution network are computed using the Hazen-Williams formula. The distribution network has been carried out utilizing the Water GEMS computer program. The peak hour demand analysis is conducted considering the maximum day demand and peak hour factor of 1.8; whereas the minimum demand analysis is carried out considering its flow factor and a maximum daily demand of the system.it can be seen that the available minimum head at most nodes also, except at few nodes which are located at lower level of the town, there are no nodes that will be submitted to a pressure higher than 80m during minimum demand. However, for such nodes a pressure reducing valve is recommended at node as they are supplied from one main outlet gravity pipe from existing $50m^3$ service reservoirs. As shown on (Appendix-8) the velocity, during the peak flow through some pipe section is low for pipes having a diameter of 50mm .In the Holeta distribution system the maximum and minimum pressure head has not limits as well as maximum and minimum flow velocities.

Table 4-9 DISTRIBUTION OF PRESSURE IN THE SYSTEM

Pressure(m H2O)	Percentage (%)
Below 20	1.5%
21-30	5.8%
31-40	12.3%
41-50	16%

51-60	15%
61-70	26%
Greater than 70	23%

The result shows that the pressure is high at morning time. the discharge and velocity is flow within the same line of action.

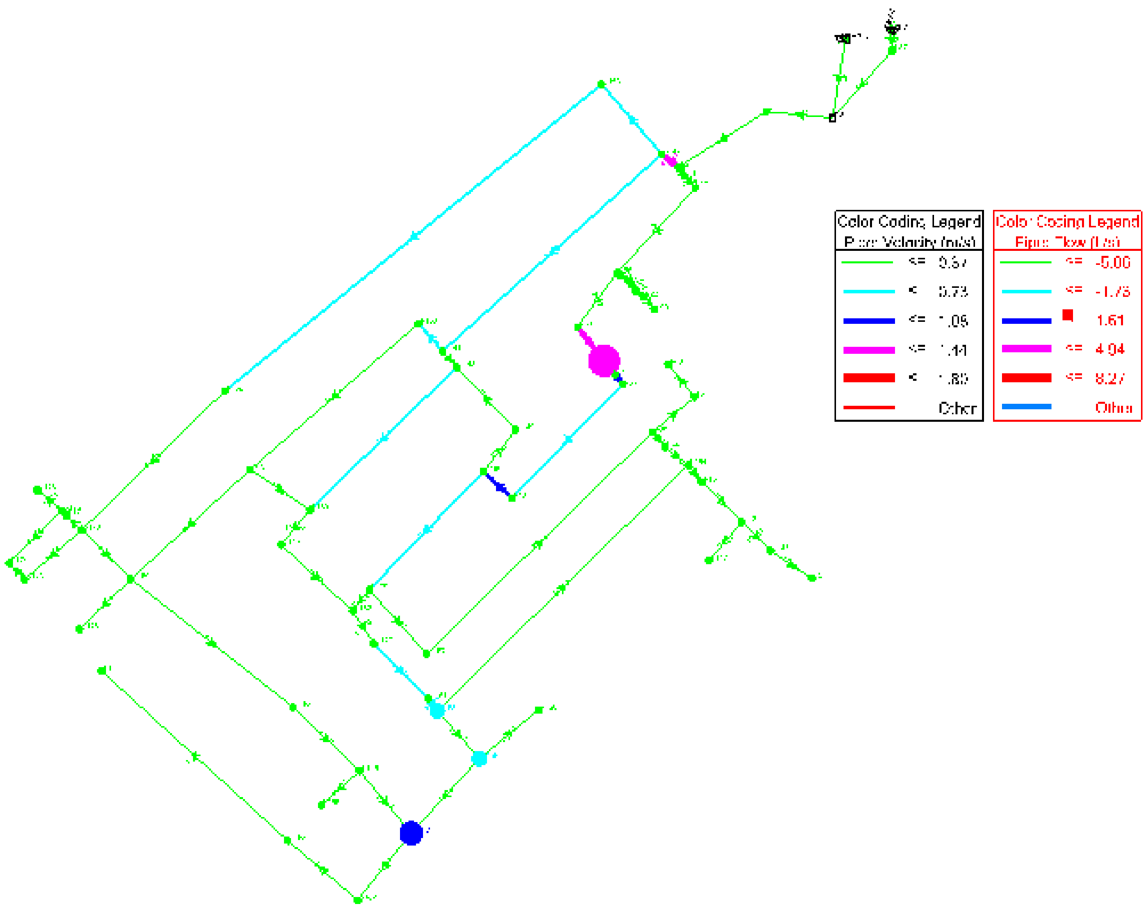


Figure 8 **Hydraulic net of the system**

4.5.2. Calibration and Validation

The credibility of analysis is merely evident if analysis of result precisely reflects observed field values. Thus, to have a confidence on analysis result it needs to calibrate a system. An effort to perform hydraulic network calibration and validation for this case study is presented as follows.

Calibration is the process of comparing the analysis results to field observations and, if necessary, adjusting the data describing the system until system predicted performance reasonably agrees with measured system performance over a wide range of operating conditions.

Even though the required data have been collected and entered into a hydraulic simulation software package, the system can not assume that the analysis is an accurate mathematical representation of the system. The hydraulic simulation software simply solves the equations of continuity and energy using the supplied data; thus, the quality of the data will dictate the quality of the results. The accuracy of a hydraulic network depends on how well it has been calibrated, so a calibration analysis should always be performed before a system is used for decision making purposes.

Table 4-10 **Observed and Simulated pressure**

Time(hr)	Pressure Junction	Observed pressure(m)	Simulated Pressure(m)
7:00AM	J-1	40	31
	J-151	41	37
	J-180	81	58
	J-37	90	87
	J-62	74	76
	J-165	63	51
	J-57	95	100
	J-173	75	63
	J-182	44	50
	J-157	61	54
2:00PM	J-1	47	32

	J-151	45	59
	J-180	55	67
	J-37	88	89
	J-62	45	35
	J-165	61	77
	J-57	104	101
	J-173	73	85
	J-182	63	76
	J-157	61	80
6:00PM	J-1	35	32
	J-151	48	54
	J-180	61	63
	J-37	92	89
	J-62	77	83
	J-165	92	71
	J-57	99	101
	J-173	77	80
	J-182	82	70
	J-157	68	73

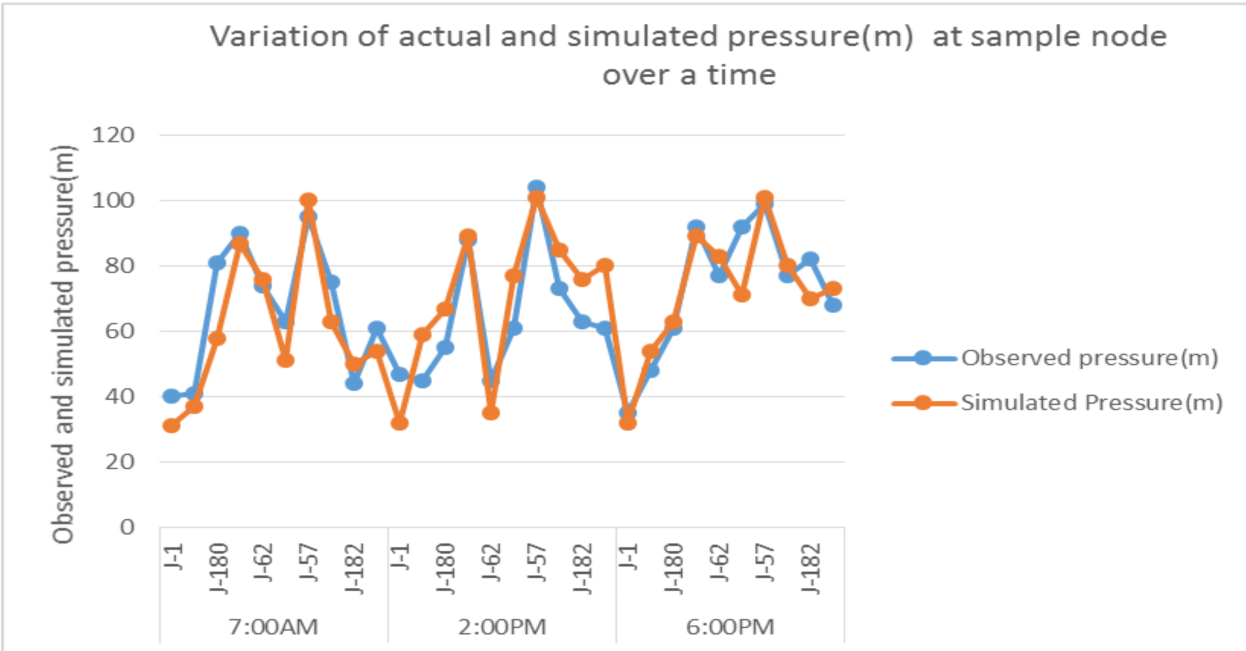


Figure 9 Actual and simulated pressure at samples node

Pressures were measured in the field in order to compare with the results of the distribution system. The measurements covered a wide range of subsystems and branch to get a representative sample. Figure-9 is a comparison plot of observed pressures versus calculated pressures at various taps throughout the system. The diagonal line on the plot represents the line of perfect correlation in Figure -10 below here. Ideally all the points should align themselves on this line; meaning that all observed pressures would be equal to the computed pressures, giving a correlation coefficient of 1 that is the best correlation between observed and simulated. The linear correlation coefficient (R) of observed versus computed pressures is calculated by Equation 3-10 value is at 0.8527. The coefficient of determination (R2) value was 0.8527, it indicates that observed and simulated relation is strongly as values tend to 1.

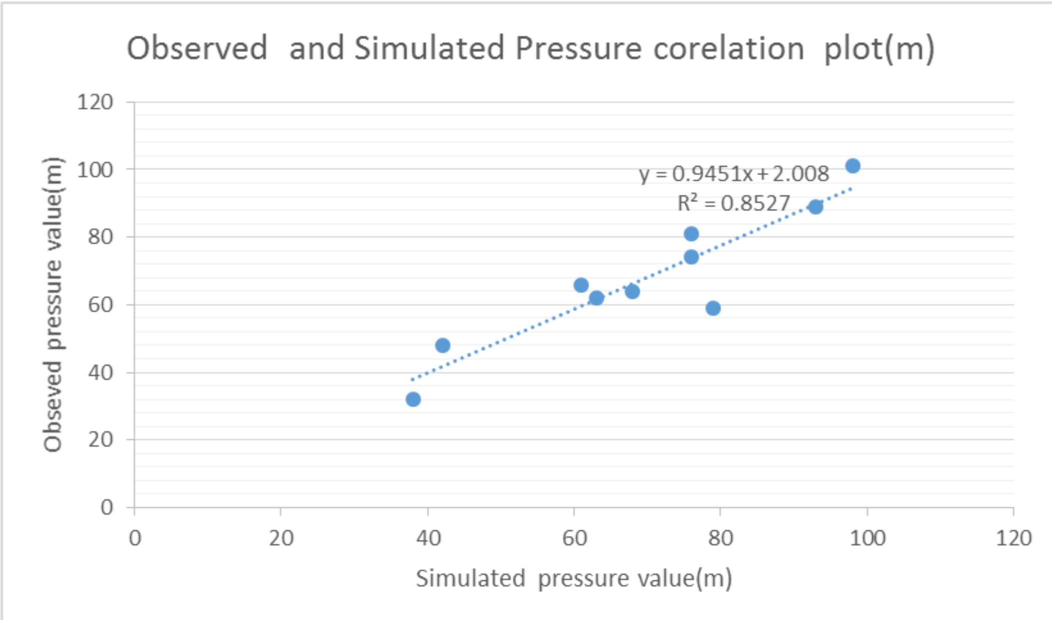


Figure 10 **Correlation between observed and simulated pressure parameters**

One reassuring fact with respect to Figure 9 is that the discrepancy between observed and computed pressures seems to be random rather than systematic. Indeed, one can observe both over-estimates and under-estimates of calculated pressures, at all ranges, and there is no particular tendency by subsystem either. If anything, one might observe a tendency to under-estimate pressures, but considering that minor head-losses have been ignored, this fact is most likely due to the small sample size.

4.5.3. Calibration Based on Difference Error

The degree of accuracy varies depending on the size of the system and the amount of field data and testing available to the modeler. (Bentely,2008) states that the average difference of ±1.5m to a maximum of ± 5.0m for a good data set and ± 3.0 to ± 10m for a bad data set would be a reasonable target. this is in terms of comparing the observed versus the calculated pressure and heads in the system.

Table 4-11 **Junction pressure calibration based on degree of accuracy criteria**

S.no	Pressure Junction	Observed pressure(m)	Simulated Pressure(m)	Difference pressure error (m)
1	J-1	38	32	6
2	J-151	42	48	-6
3	J-180	79	59	20
4	J-37	93	89	4
5	J-62	76	81	-5
6	J-165	68	64	4
7	J-57	98	101	-3
8	J-173	76	74	2
9	J-182	63	62	1
10	J-157	61	66	-5
Average Error				**1.8**

As shown in Table 4.12, computed values are within an average error of 1.8m pressure simulated to observed values. Hence, the model is acceptable calibrated which is satisfied the setting pressure calibration and validation criteria under average level (average +1.5m to the maximum +5m).

4.6. Physico Chemical Water Quality Results of Water Source, Reservoir and Water Taps

The physic-chemical parameters directly related to the safety of the drinking water to human consumption. 31 samples collected at different components of existing water supply system from source to point of distribution were tested. The physical and chemical water quality parameters tested in the laboratory were pH**,** Temperature (^{0}C), Turbidity, Total Dissolved solids (TDS), Electrical Conductivity (EC), Residual chlorine, total hardness (TH), Ca (hardness) and Mg (hardness).

To reach at acceptable and finalized conclusion about water quality it is important to start from source and then pull out up to point of use. The results of this study on water quality at Water source, Reservoir and Consumers tap for selected parameters PH, Temperature; Total dissolved solid, electrical conductivity, Hardness, Residual chlorine and Turbidity.

4.6.1. PH

The balance of positive hydrogen ions (H+) and negative hydroxide ions (OH-) in water determines how acidic or basic. The water is substances with a pH higher than 7.0 (7.1-14.0) are considered alkaline or basic. Substances with a pH less than 7.0 (0 - 6.9) are considered acidic. According to the WHO, the minimum and maximum allowable pH ranges from 6.5 to 8.5 for portable water (Appendix Table 56). The pH of water is controlled by the equilibrium achieved by dissolved compounds in the system. In natural waters, the pH is primarily a function of the carbonate system, which consists of bicarbonate and carbonate. Acid inputs to a water system may substantially alter the PH.

There is no health risks related to consuming slightly acidic or basic water. However, when water has a pH that is too low (at HHT -13 to HHT-15), it will lead to corrosion and pitting of pipes in plumbing in distribution systems. Acidic water can be corrected using one of the following two methods:
1. Neutralizing filters increase the pH by passing water through a filter bed of Calcium Carbonate ($CaCO_3$). This neutralizes the acid and increases the PH.

2. Soda Ash (Sodium Carbonate) solution is fed through a tube into the pumping intake and is automatically injected whenever the water pump is running.
The pH values range from 7.1 to 8.5 for most of the sample

The water represents the samples collected from Source S-4 and S-5 ahas high concentration of pH which is above the WHO Guideline standard and Ethiopia standard. At high PH, a cause incrustation (scale built –up) in plumbing can cause aesthetic problems & that makes bitter test (alkali test) Likewise, The pH pattern of tap water samples is closer to the reservoir water pH 7 to -8.5 than the source water (pH 6.85-9.66). This shows that, like temperature, there is a decrease as water discharges from the source water to the reservoir and tap water systems. The pH of water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in Household water systems (WHO, 2008). Lower pH water is likely to be corrosive. Whereas Higher pH value requires longer contact time (CT) and high free chlorine residual (FCR) for effective chlorine disinfection .From this pH value of water source was under an acceptable range to be used for dinking purpose.

Drinking water with higher levels of pH does not pose a health risk; however will have bitter taste that may reduce the aesthetic acceptability of water.

In general, In general, water with a pH of 7 is considered neutral while lower than this referred acidic and a pH greater than 7 known as basic. Normally, water pH ranges from 6.5 to 8.5. It is noticed that water with low PH tends to be toxic and with high degree of PH, it is turned into bitter taste. According to the WHO standards, pH of water should be 6.5 to 8.5 it is significant to measure PH at the similar time as chlorine residual since the effectiveness of disinfection with chlorine is extremely pH dependent: where the pH exceeds 8.0, disinfection is less effective. To check that the pH is in the optimal range for disinfection with chlorine (less than 8.0), simple tests may be conducted in the field using comparators such as that used for chlorine residual. Physico-chemically it is safe except S-4 and S-5greater than 8.5 and at HHT-13, HHT -14 and HHT-15 shows the result below than 6.5. The overall PH records of water samples from the sources were more than 85% of the sample is found belongs slightly basic.

4.6.2. Temperature

Temperature affects both biological and chemical functions. There are High water temperature at HHT-15 to HHT-17 (Appendix-A-3) this result enhances the growth of microorganisms and may increase taste, odor, and color problems of drinking water.

The most desirable temperature for public water supply is between 4 °C and 10 °C. Temperatures above 25 °C are undesirable. Temperature is one of the physico-chemical parameters used to evaluate water quality of Potable water. The data showed that the highest temperature of 24.35 °C from source water

the water samples from the eight wells (water sources) did not show significant difference amongst one another.almost 30% of the tap water samples were found to be below the temperature range of 20 °C-24 °C this result shows that the temperature is change quickly, the PH change with a matter of minutes.

4.6.3. Turbidity

Turbidity is a measure of the degree of cloudiness or muddiness of water. Turbidity is important because it touches both the acceptability of water to consumers, and the selection and competence of treatment

Processes, particularly the efficiency of disinfection with chlorine since it uses a chlorine demand, defend microorganisms, and may stimulate the growth of bacteria.

The highest and lowest turbidity measurements were recorded from water Taps samples of HHT-1 and HHT -17 and the lowest is recorded at S-9 respectively. As far as the turbidity of the water samples from the reservoir is concerned, the Result showed turbidity measurement ranging from 2.14NTU to that of 4.2NTU, with no significant difference within samples. It is interesting to note that the reservoir water showed a slight decrease (average 2.14NTU) in turbidity when compared to the source water.

4.6.4. Total Dissolved Solid and Electrical Conductivity

The measurements on total dissolved solids (TDS) samples were found to fall within 96-241mg/l (TDS) and electrical conductivity (EC) of Source water samples were found to fall within 192.75-351mg/l (EC) (appendix A-6) in the sample result. The average EC Values of all water source samples was calculated as312μS/cm which is comparable to the slightly lower value the standard.

Generally, TDS and EC values showed the same pattern in different wells. The TDS values of tap water samples fell below the maximum acceptable standard of 600mg/l (WHO, 2006). The amount of dissolved solids in water concludes that the electrical conductivity.

4.6.5. Free Residual Chlorine

To overcome any contamination that might enter to the distribution system, to inhibit biofilm formation and to stabilize water quality within the distribution system free chlorine residual must be maintained. For this reason WHO and ES allow a free chlorine residual of 0.1-0.5mg/L. from all source and reservoirs there is no any chlorination system so it is most needed That to obey the standard and amount of free chlorine from to 0.1to 0.5mg/L to be sufficient for the whole disinfection process along the distribution system But in this study, the concentrations of residual free chlorine in all sample the result is Nill. This water points consists of disinfection agent less than the standard which may indicate possibility inefficiency of disinfection in the distribution system and require an excessive disinfectant.

This study directly related at all water samples tested for free chlorine residual 100% is 0.00 of it had a value of less than 0.5mg/l. This may be the result of any of the following conditions: The age of the water in the system since it was treated; Microbial re-growth within the distribution system and Reaction with corrosion byproducts; and Cross-connection or other contamination that consumes the disinfectant (Appendix A-8).

Table 4-12 PHYSICO CHEMICAL TEST RESULT AVERAGELY FROM TWICE TEST

S.N	Sample types	Result of twice test and physico chemical Parameter test Averagely.						Remark
S.N	Sample types	PH	Temp .(℃)	Turbidity. (NTU)	TDS. (mg/l)	E.C(μS/cm)	Res.Ch.	Comparing to WHO and Ethiopia Standard (Physico chemically)
1	S-1	8.405	22.05	3.26	114	228	Nil	safe
2	S-2	8.325	20.9	2.33	128.5	257	Nil	safe
3	S-3	8.42	23	2.7	102.5	205.85	Nil	safe
4	S-4	9.495	22.95	3.27	96	192.75	Nil	PH,at source is Above the standard
5	S-5	9.665	23	2.97	241	344.4	Nil	PH,at source is Above the standard
6	S-6	7.25	23.5	3.48	120.5	241	Nil	safe
7	S-7	6.85	22.75	3.087	149.5	299	Nil	safe

8	S-8	9.08	23.5	3.038	125	250	Nil	PH,at source is Above the standard
9	S-9	7.84	22.45	3.058	158.5	317	Nil	safe
10	R-1	7.405	20.95	3.64	137	274	Nil	safe
11	R-2	8.53	22.8	3.006	111	222	Nil	safe
12	R-4	7.8	23.2	3.54	153.5	307	Nil	safe
13	HHT-1	8.39	22.55	2.8	241	351	Nil	safe
14	HHT-2	6.19	23.3	3.48	138.5	277	Nil	PH,at source is below standard
15	HHT-3	8.335	23.5	2.45	103.5	207	Nil	safe
16	HHT-4	8.175	23.27	4.09	126.5	253	Nil	safe
17	HHT-5	8.19	23.6	2.14	106	212	Nil	safe
18	HHT-6	7.66	22.5	4.2	114.5	229	Nil	safe
19	HHT-7	7.3	23.35	3.13	119	238	Nil	safe
20	HHT-8	8.195	22.55	3.15	125.5	251	Nil	safe
21	HHT-9	8.015	20.5	3.97	130.5	261	Nil	safe
22	HHT-10	8.375	21.25	4.06	173.5	347	Nil	safe
23	HHT-11	8.185	22.35	3.81	143.5	287	Nil	safe
24	HHT-12	7.1	23.27	2.59	136.5	273	Nil	safe

25	HHT-13	6.39	23.35	3.02	126	252	Nil	PH,at source is below standard
26	HHT-14	6.255	24.35	4.18	120.5	241	Nil	PH,at source is below standard
27	HHT-15	6.29	24.35	2.9	129	258	Nil	PH,at source is below standard
28	HHT-16	7.35	24.35	2.5	144.5	289	Nil	safe
29	HHT-17	7.265	22.5	3.9	123.5	247	Nil	safe
30	HHT-18	7.67	23.45	2.9	107.5	215	Nil	safe
31	HHT-19	7.65	23.6	2.8	112	224	Nil	safe

4.6.6. Hardness

Hardness of drinking water is due firstly to calcium and magnesium carbonates and bicarbonates (which can be removed by boiling) and calcium and magnesium sulfate and chloride (which can be removed by chemical precipitation using lime and sodium carbonate).

The laboratory results shown in (Table A-1) and shows that the values range between the result range the concentration between 0 to 50 mg/l and mostly 85% is belongs to 50 to 150 mg/l. Therefore, the degree of hardness of the Holeta town water supply can be categorized as soft and moderately soft water, which is not harmful for consumers according to the WHO standards.

Table 4-13 WATER QUALITY TEST RESULT FOR HARDNESS

SN	Sample types	Result test of total hardness			WHO standard	Ethiopian standard
		T.Hard.mg/l as caco3	cal.Hard.mg/l as caco3	Mag.Hard.mg/l as caco3		
1	S-1	142	95	47	300mg/l	300mg/l
2	S-2	86	62	24	300mg/l	300mg/l
3	S-3	102	57	45	300mg/l	300mg/l
4	S-4	94	71	23	300mg/l	300mg/l
5	S-5	65	52	13	300mg/l	300mg/l
6	S-6	26	12	14	300mg/l	300mg/l
7	S-7	80	67	13	300mg/l	300mg/l
8	S-8	59	43	16	300mg/l	300mg/l

9	S-9	82	65	17	300mg/l	300mg/l
10	R-1	108	78	30	300mg/l	300mg/l
11	R-2	94	62	32	300mg/l	300mg/l
12	R-4	92	82	10	300mg/l	300mg/l
13	HHT-1	87	73	14	300mg/l	300mg/l
14	HHT-2	50	38	12	300mg/l	300mg/l
15	HHT-3	60	40	20	300mg/l	300mg/l
16	HHT-4	90	81	9	300mg/l	300mg/l
17	HHT-5	48	29	19	300mg/l	300mg/l
18	HHT-6	45	31	14	300mg/l	300mg/l
19	HHT-7	98	67	31	300mg/l	300mg/l
20	HHT-8	93	82	11	300mg/l	300mg/l
21	HHT-9	54	43	11	300mg/l	300mg/l
22	HHT-10	60	38	22	300mg/l	300mg/l
23	HHT-11	76	63	13	300mg/l	300mg/l
24	HHT-12	92	69	23	300mg/l	300mg/l
25	HHT-13	83	61	22	300mg/l	300mg/l
26	HHT-14	48	35	13	300mg/l	300mg/l
27	HHT-15	83	52	31	300mg/l	300mg/l

28	HHT-16	78	64	14	300mg/l	300mg/l
29	HHT-17	43	31	12	300mg/l	300mg/l
30	HHT-18	92	65	27	300mg/l	300mg/l
31	HHT-19	74	51	23	300mg/l	300mg/l

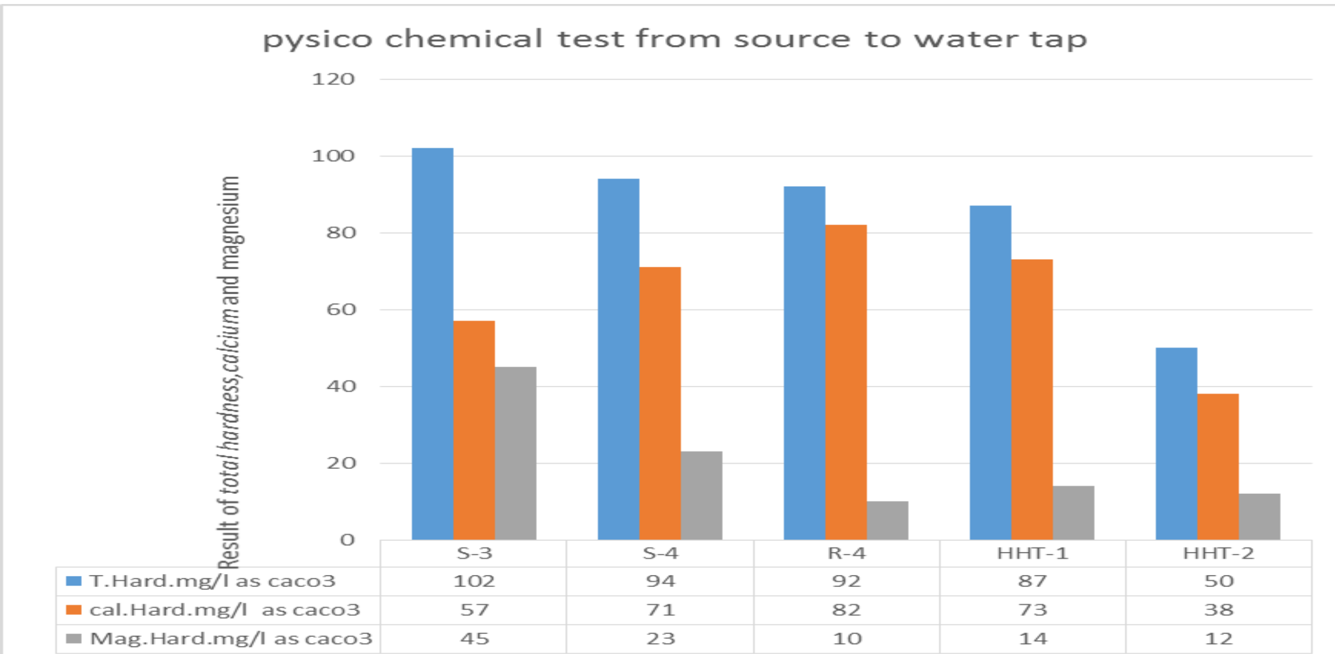


Figure 11 PHYSICO CHEMICAL FOR HARDNESS

4.7. Bacteriological Water Quality of Source, Reservoir and Tap Water

The usefulness of water for human use is determined by its quality. Quality is a major determinant for the health of ecosystems. Proper monitoring and assessment of the quality of surface, ground and tap water is essential for efficient water quality management, which in turn can ensure human welfare and environmental sustainability.

So that the bacteriological quality of the water delivery system of Holeta Town, states for the parameters of the total coli forms (TC) and fecal coli forms (FC) was tested from the water sources, distribution points (reservoirs), and distribution networks (tap water) from different Kebele's. Generally at the source, reservoir and Water Point tap bacteriological the result it is safe and it shows low risk.

4.7.1. Total coli form

Total coli forms were used as indicator bacteria to assay the level of bacteriological contamination of the water supplies. A total of 31 water samples were analyzed for Total coli forms and the result indicates water taps and other shows low risk counted below 50 in number. Generally result indicates that chlorine is needed in the distribution systems to be applied to assure a better quality of drinking water.

4.7.2. Fecal coli form

100% of household samples tested in for all sample selected from the total study area shows no existence of (fecal) coli form. In drinking water presence of fecal coli form should not be ignored as the basic assumption that pathogens would not be presented in drinking water.

In this study the average count of fecal coli forms were below the recommended value of WHO and Ethiopian Standards.

Generally, from bacteriological water quality tests all sample tap water samples meet the standard set by WHO and Ethiopia. Due to this the samples failed to safe water quality with regard to TC and FC criteria of 0 CFU/100ml.

During field visit it is observed that there is no any treatment in water supply system at the source and at the reservoir. The water from the reservoir is distributed to the consumers without any treatment method.

It is also observed that the water produced from Bore Hole one and borehole two is directly pumped to the distribution system for customers. And the water produced from BH-4and BH-8 is pumped to the distribution system and to consumers without any treatment through distribution pipe connected to the Galgal Kuyu Reservoirs one.

Even though there is water quality laboratory at Holeta town water utility office compound bacteriological and Physico-chemical water quality test is not conducted periodically and sanitary inspection for existing water supply system and newly developing sources is not carried out periodically as per the Ethiopian guideline for drinking water quality. Generally result indicates that chlorine is needed in the distribution systems to be applied to assure a better quality of drinking water.

Table 4-14 WATER QUALITY TEST RESULT FOR COLI FORM

SN	Sample types	Coli form		WHO Standard	Ethiopian standard
		Result of Total coli form(TCC) ml	Result of Fecal coli form(FCC) ml		
1	S-1	3	Nil	0/100ml	0/100ml
2	S-2	8	Nil	0/100ml	0/100ml
3	S-3	10	Nil	0/100ml	0/100ml
4	S-4	18	Nil	0/100ml	0/100ml
5	S-5	5	Nil	0/100ml	0/100ml
6	S-6	9	Nil	0/100ml	0/100ml
7	S-7	8	Nil	0/100ml	0/100ml
8	S-8	19	Nil	0/100ml	0/100ml
9	S-9	12	Nil	0/100ml	0/100ml
10	R-1	2	Nil	0/100ml	0/100ml

11	R-2	6	Nil	0/100ml	0/100ml
12	R-4	3	Nil	0/100ml	0/100ml
13	HHT-1	22	Nil	0/100ml	0/100ml
14	HHT-2	32	Nil	0/100ml	0/100ml
15	HHT-3	17	Nil	0/100ml	0/100ml
16	HHT-4	24	Nil	0/100ml	0/100ml
17	HHT-5	52	Nil	0/100ml	0/100ml
18	HHT-6	41	Nil	0/100ml	0/100ml
19	HHT-7	4	Nil	0/100ml	0/100ml
20	HHT-8	11	Nil	0/100ml	0/100ml
21	HHT-9	7	Nil	0/100ml	0/100ml
22	HHT-10	8	Nil	0/100ml	0/100ml
23	HHT-11	7	Nil	0/100ml	0/100ml
24	HHT-12	8	Nil	0/100ml	0/100ml
25	HHT-13	23	Nil	0/100ml	0/100ml
26	HHT-14	4	Nil	0/100ml	0/100ml
27	HHT-15	34	Nil	0/100ml	0/100ml
28	HHT-16	5	Nil	0/100ml	0/100ml
29	HHT-17	8	Nil	0/100ml	0/100ml

30	HHT-18	29	Nil	0/100ml	0/100ml
31	HHT-19	35	Nil	0/100ml	0/100ml

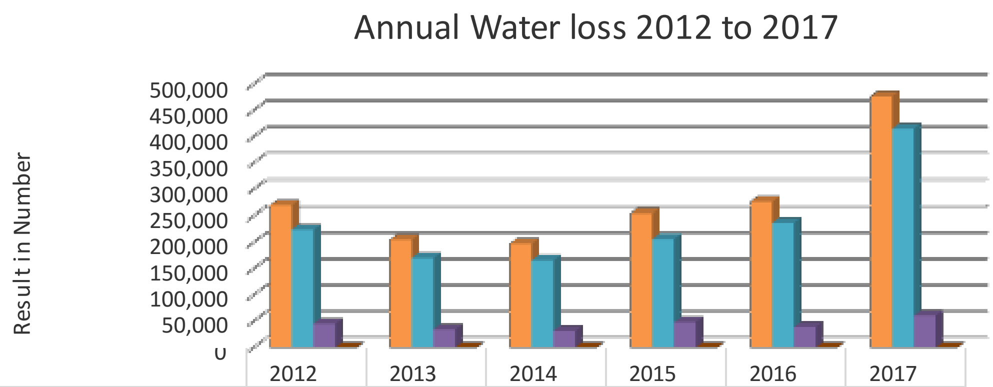
4.8. Water loss

Amount of water loss compared with water production and water consumption in the year 2015 is high. Measured loss from Holeta town starting to 2012 to 2017 (Appendix Table 62 to Table 67).

The total annual water produced and distributed to the distribution system and the water billed that was aggregated from the individual customer meter readings were used to quantify the total water loss for the town .All the result is below 20% but if we reduce that the percentage of the water supply coverage is increase.

The water production and consumption of the water supply service are assessed based the past five years record. The production figures are taken from the water meter installed at the source and the consumption is read from the water meters installed for the customers and public fountains. The five years actual production and consumption figures obtained from the town water supply service is presented.

As per the result of the average water loss for the year 2017 is calculated shows that 13% of the average water production which is low and a matter of concern. In other words, out of the average monthly water production in 2017 which was 476,752m3 the amount consumed was 415,493m3 and the water loss was 61,259m3. As the water loss is reduced the water supplycoverage can be increased.



	2012	2013	2014	2015	2016	2017
1 Annual Water production in m3	269,740	205,201	197,632	254,889	276,752	476,752
2 Annual Water Consumption	224,225	170,317	165,835	206,450	237,080	415,493
3 Annual Water loss	45,515	34,884	31,797	48,439	39,672	61,259
4 Water loss %	16.87%	17%	16%	19%	14%	13%

Figure 12 ANNUAL WATER LOSS OF THE TOWN

4.8.1. Possible reasons of high water loss

Water loss from transmission caused by over flow from tankers due to absence or malfunctions of automatic flow control valve or float valves, Metered but unbilled water like the water point connected to pressure line which carries water from BH-3 to Galgal kuyu reservoir which provides water to walmara community along the pressure line. Leakage from pumping station, inlet pipes from qeransa boreholes two and three.

Figure a) over flow from Figure b) leakage on site Figure c) Crack at Goro Kerensa reservoir

Figure 13 WATER LEAKAGE (SOURCE: - SITE VISIT)

Leakage from corroded, old defective and broken pipes, Leakage and overflow at service reservoirs Water loss caused by metering inaccuracies, Unbilled metered consumption, Unbilled unmetered consumption or illegal connection, Unbilled metered consumption, Leakage on service connections up to point of customer metering, Leakage caused by connecting distribution pipes lines and Leakage due poor workmanship and using of nonstandard pipes and fittings. Generally there are no water meters installed within the distribution pipe network from Galgal Kuyu Reservoir, Water loss from Reservoir is mostly caused by overflow due to absence of float valves is the reason of water loss.

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATION

5.1. Conclusions

The primary aim of this research was to assess the performance of water supply system beside existing water supply system, demand of the town, and water quality and water loss in Holeta, Ethiopia.

- Both the water supply coverage and the city distribution were evaluated based on the daily per capital consumption and level of connection using the population data of the city. The average water supply coverage of the city is found to be 20.68l/per/day.

- The water supply coverage of the town was very low 52.57%. Although there is overall shortage of water in the town, predominantly the existing amount of water is fairly distributed among the different localities except few kebeles that consumed much water although their number of population is either low or moderate and vice versa.

- With respect to bacteriologic ally quality of the water sources, reservoir and water taps out of 31 sampling points the entire sample is Nill, concerning physico-chemically almost all the water sources are potable. If sanitary measures are taken and some technical problems are solved the sources can supply drinking water of good quality.

- Physico-chemically, except, PH in some number of samples, the results of all the other measured parameters are within the range of the limit set for drinking water.

- Water samples were collected from the distribution source and from household taps in both cities. The samples were then tested for various physical, chemical and biological water quality parameters.

- Despite the low water coverage of the city, the total water loss is found to be high Within 2017 Year from the total number of produced water 476,752 cubic meters and the annual water loss as derived using the above expression was 61,259 cubic meters which account to 13%.

5.2. Recommendations

Based on the finding of the study the following recommendations are to customers' satisfaction, water quality; water loss has been proposed respectively to improve the performance of existing Holeta town water supply system.

- The system of water supply system needs detail study before distribution pipe expansion.
- The water utility should work towards making water to be available for the whole day by developing additional sources to increase the water production and by reducing the high water loss.
- It is Bacteriological and chemical water quality test be conducted periodically at least four times a year.
- Proper implementation and sufficient disinfection of water with chlorine is a Prime importance.
- The present work is limited to few Physico-chemical parameters and Sampling frequency .Therefore, year round sampling and analysis of additional water quality parameters.
- The water utility need to respond immediately to maintenance requests of customers to avoid complaints from customers and need to have planned and regular discussions with the customers and should conduct a regular survey to know customer's satisfaction level and the service deficiencies and should make improvements on its service to increase the customer's satisfaction.
- Holeta Water supply office should gather the X, Y, coordinates of its Water supply distribution system from source to customer water meters to know and evaluate hydraulic system using Water GEMS with GIS integrated software, for more precise and faster way of in demand allocation. it needs to be documented in a well-organized way . In general ,All relevant documents, feasibility studies, borehole history, manufacturer manuals and detail designs, as built drawings of all existing water supply system components for the sources, reservoirs, pump houses etc need to be documented in a well-organized way and should be available in the water utility office for future reference is strongly recommended.

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Annexes

Appendix A:- Physico chemical and Biological Water quality Analysis Report

Table A-1 Total Hardness

Holeta Town Water Supply Authority

Water Quality Control Service

Physico Chemical and Biological Water Quality Analysis Report

1. Water quality test result for total hardness

SN	Sample types	Result test of total hardness			WHO standard	Ethiopian standard
		T.Hard.mg/l as $CaCO_3$	cal.Hard.mg/l as $CaCO_3$	Mag.Hard.mg/l as $CaCO_3$		
1	S-1	142	95	47	300mg/l	300mg/l
2	S-2	86	62	24	300mg/l	300mg/l
3	S-3	102	45	57	300mg/l	300mg/l
4	S-4	94	71	23	300mg/l	300mg/l
5	S-5	65	52	13	300mg/l	300mg/l
6	S-6	26	12	14	300mg/l	300mg/l
7	S-7	80	67	13	300mg/l	300mg/l
8	S-8	59	43	16	300mg/l	300mg/l
9	S-9	82	65	17	300mg/l	300mg/l
10	R-1	108	78	30	300mg/l	300mg/l

11	R-2	94	62	32	300mg/l	300mg/l
12	R-4	92	82	10	300mg/l	300mg/l
13	HHT-1	87	73	14	300mg/l	300mg/l
14	HHT-2	50	38	12	300mg/l	300mg/l
15	HHT-3	60	40	20	300mg/l	300mg/l
16	HHT-4	90	81	9	300mg/l	300mg/l
17	HHT-5	48	29	19	300mg/l	300mg/l
18	HHT-6	45	31	14	300mg/l	300mg/l
19	HHT-7	98	67	31	300mg/l	300mg/l
20	HHT-8	93	82	11	300mg/l	300mg/l
21	HHT-9	54	43	11	300mg/l	300mg/l
22	HHT-10	60	38	22	300mg/l	300mg/l
23	HHT-11	76	63	13	300mg/l	300mg/l
24	HHT-12	92	69	23	300mg/l	300mg/l
25	HHT-13	83	61	22	300mg/l	300mg/l
26	HHT-14	48	35	13	300mg/l	300mg/l
27	HHT-15	83	52	31	300mg/l	300mg/l
28	HHT-16	78	64	14	300mg/l	300mg/l
29	HHT-17	43	31	12	300mg/l	300mg/l
30	HHT-18	92	65	27	300mg/l	300mg/l
31	HHT-19	74	51	23	300mg/l	300mg/l

Analyzed By: Rata Fikadu — Date of Laboratory test: April 23-30/2018 — Signature:

Approved By: Tafa Tolasa — Head Water Quality Control Service — Signature

2. Water quality test result for PH

SN	Sample types	Test-1	Test-2	Ave.	WHO standard	Ethiopian standard
1	S-1	8.49	8.32	8.405	6.5-8.5	6.5-8.5
2	S-2	8.37	8.28	8.325	6.5-8.5	6.5-8.5
3	S-3	8.44	8.40	8.42	6.5-8.5	6.5-8.5
4	S-4	9.57	9.42	9.495	6.5-8.5	6.5-8.5
5	S-5	9.83	9.5	9.665	6.5-8.5	6.5-8.5
6	S-6	7.4	7.1	7.25	6.5-8.5	6.5-8.5
7	S-7	6.9	6.8	6.85	6.5-8.5	6.5-8.5
8	S-8	9.26	8.9	9.08	6.5-8.5	6.5-8.5

Table A-2 PH Test

9	S-9	8.18	7.5	7.84	6.5-8.5	6.5-8.5
10	R-1	7.61	7.2	7.405	6.5-8.5	6.5-8.5
11	R-2	8.76	8.3	8.53	6.5-8.5	6.5-8.5
12	R-4	7.5	8.1	7.8	6.5-8.5	6.5-8.5
13	HHT-1	8.53	8.25	8.39	6.5-8.5	6.5-8.5
14	HHT-2	6.28	6.1	6.19	6.5-8.5	6.5-8.5

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15	HHT-3	8.35	8.32	8.335	6.5-8.5	6.5-8.5
16	HHT-4	8.15	8.2	8.175	6.5-8.5	6.5-8.5
17	HHT-5	8.23	8.15	8.19	6.5-8.5	6.5-8.5
18	HHT-6	7.82	7.5	7.66	6.5-8.5	6.5-8.5
19	HHT-7	7.4	7.2	7.3	6.5-8.5	6.5-8.5
20	HHT-8	8.19	8.2	8.195	6.5-8.5	6.5-8.5
21	HHT-9	8.23	7.8	8.015	6.5-8.5	6.5-8.5
22	HHT-10	8.35	8.4	8.375	6.5-8.5	6.5-8.5
23	HHT-11	8.47	7.9	8.185	6.5-8.5	6.5-8.5
24	HHT-12	6.9	7.3	7.1	6.5-8.5	6.5-8.5
25	HHT-13	6.28	6.5	6.39	6.5-8.5	6.5-8.5
26	HHT-14	6.31	6.2	6.255	6.5-8.5	6.5-8.5
27	HHT-15	6.18	6.4	6.29	6.5-8.5	6.5-8.5
28	HHT-16	7.5	7.2	7.35	6.5-8.5	6.5-8.5
29	HHT-17	7.43	7.1	7.265	6.5-8.5	6.5-8.5
30	HHT-18	7.64	7.7	7.67	6.5-8.5	6.5-8.5
31	HHT-19	7.85	7.45	7.65	6.5-8.5	6.5-8.5

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

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Table A-3 Temperature

3. Water quality test result for Temperature

S.N	Sample types	Result of Test 1 (°c)	Test 2 (°c)	Ave. (°c)	WHO Standard (°c)	Ethiopian Standard (°c)
1	S-1	22.1	22	22.05	25	25
2	S-2	20.3	21.5	20.9	25	25
3	S-3	23.2	22.8	23	25	25
4	S-4	23.4	22.5	22.95	25	25
5	S-5	22	24	23	25	25
6	S-6	24	23	23.5	25	25
7	S-7	22.8	22.7	22.75	25	25
8	S-8	23.7	23.3	23.5	25	25
9	S-9	22.5	22.4	22.45	25	25
10	R-1	21.1	20.8	20.95	25	25
11	R-2	22.7	22.9	22.8	25	25
12	R-4	23	[illegible]	[illegible]	25	25
14	HHT-2	23.2	23.4	23.3	25	25
15	HHT-3	23.4	23.6	23.5	25	25
16	HHT-4	23.4	[illegible]	23.27	25	25

17	HHT-5	23.7	23.5	23.6	25	25
18	HHT-6	23	22	22.5	25	25
19	HHT-7	23.9	22.8	23.35	25	25
20	HHT-8	22.4	22.7	22.55	25	25
21	HHT-9	21	20	20.5	25	25
22	HHT-10	22.5	20	21.25	25	25
23	HHT-11	22.2	22.5	22.35	25	25
24	HHT-12	23	23.54	23.27	25	25
25	HHT-13	23.7	23	23.35	25	25
26	HHT-14	24.1	24.6	24.35	25	25
27	HHT-15	24.7	24	24.35	25	25
28	HHT-16	24.3	24.4	24.35	25	25
29	HHT-17	23	22	22.5	25	25
30	HHT-18	23.9	23	23.45	25	25
31	HHT-19	23.5	23.7	23.6	25	25

Analyzed By: Rata Fikadu Date of Laboratory test: April 23-30/2018 Signature:

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Table A-4 Coli form test

4. Water quality test result for coli form

SN	Sample types	Coli form		WHO Standard	Ethiopian standard	Remark
		Result of Total coli form(TCC) ml	Result of Fecal coli form(FCC) ml			
1	S-1	3	Nil	0/100ml	0/100ml	Low Risk
2	S-2	8	Nil	0/100ml	0/100ml	Low Risk
3	S-3	10	Nil	0/100ml	0/100ml	Low Risk
4	S-4	18	Nil	0/100ml	0/100ml	Low Risk
5	S-5	5	Nil	0/100ml	0/100ml	Low Risk
6	S-6	9	Nil	0/100ml	0/100ml	Low Risk
7	S-7	8	Nil	0/100ml	0/100ml	Low Risk
8	S-8	19	Nil	0/100ml	0/100ml	Low Risk
9	S-9	12	Nil	0/100ml	0/100ml	Low Risk
10	R-1	2	Nil	0/100ml	0/100ml	Low Risk

11	R-2	6	Nil	0/100ml	0/1 00ml	Low Risk
12	R-4	3	Nil	0/100ml	0/1 00ml	Low Risk
13	HHT-1	22	Nil	0/100ml	0/1 00ml	Low Risk
14	HHT-2	32	Nil	0/100ml	0/1 00ml	Low Risk
15	HHT-3	17	Nil	0/100ml	0/1 00ml	Low Risk
16	HHT-4	24	Nil	0/100ml	0/1 00ml	Low Risk
17	HHT-5	52	Nil	0/100ml	0/1 00ml	Low Risk
18	HHT-6	41	Nil	0/100ml	0/1 00ml	Low Risk
19	HHT-7	4	Nil	0/100ml	0/1 00ml	Low Risk
20	HHT-8	11	Nil	0/100ml	0/1 00ml	Low Risk
21	HHT-9	7	Nil	0/100ml	0/1 00ml	Low Risk
22	HHT-10	8	Nil	0/100ml	0/1 00ml	Low Risk
23	HHT-11	7	Nil	[illegible]	[illegible]	Low Risk
24	HHT-12	8	Nil	0/100ml	0/1 00ml	Low Risk
25	HHT-13	23	Nil	0/100ml	0/1 00ml	Low Risk
26	HHT-14	4	Nil	0/100ml	0/1 00ml	Low Risk
27	HHT-15	34	Nil	0/100ml	0/1 00ml	Low Risk

28	HHT-16	5	Nil	0/100ml	0/100ml	Low Risk
29	HHT-17	8	Nil	0/100ml	0/100ml	Low Risk
30	HHT-18	29	Nil	0/100ml	0/100ml	Low Risk
31	HHT-19	35	Nil	0/100ml	0/100ml	Low Risk

Analyzed By: Rata Fikadu Date of Laboratory test: April 23-30/2018 Signature:

Approved By: Tafa Tolasa Head ,Water Quality Control Service Signature:

5. Water quality test result for Turbidity

SN	Sample types	Result of test1 (NTU)	Test 2 (NTU)	Ave.(NTU)	WHO standard	Ethiopian standard
1	S-1	2.66	2.45	3.26	5NTU	5NTU
2	S-2	2.02	2.31	2.33	5NTU	5NTU
3	S-3	2.25	2.4	2.7	5NTU	5NTU
4	S-4	2.54	2.57	3.27	5NTU	5NTU
5	S-5	2.35	2.52	2.97	5NTU	5NTU
6	S-6	2.4	2.9	3.48	5NTU	5NTU
7	S-7	2.45	2.52	3.087	5NTU	5NTU

Table A-5 Turbidity Result

8	S-8	2.43	2.5	3.038	5NTU	5NTU
9	S-9	2.08	2.94	3.058	5NTU	5NTU
10	R-1	2.6	2.8	3.64	5NTU	5NTU
11	R-2	2.33	2.58	3.006	5NTU	5NTU
12	R-4	2.6	2.72	3.54	5NTU	5NTU
13	HHT-1	2	2.8	2.8	5NTU	5NTU
14	HHT-2	2.5	2.78	3.48	5NTU	5NTU
15	HHT-3	2.2	2.23	2.45	5NTU	5NTU
16	HHT-4	2.8	2.92	4.09	5NTU	5NTU
17	HHT-5	2.04	2.09	2.14	5NTU	5NTU
18	HHT-6	2.98	2.8	4.2	5NTU	5NTU
19	HHT-7	2.42	2.58	3.13	5NTU	5NTU
20	HHT-8	2.45	2.57	3.15	5NTU	5NTU
21	HHT-9	2.7	2.94	3.97	5NTU	5NTU
22	HHT-10	2.9	2.8	4.06	5NTU	5NTU
23	HHT-11	2.7	2.82	3.81	5NTU	5NTU
24	HHT-12	2.21	2.34	2.59	5NTU	5NTU
25	HHT-13	2.4	2.51	3.02	5NTU	5NTU
26	HHT-14	2.94	2.84	4.18	5NTU	5NTU

27	HHT-15	2.28	2.54	2.9	5NTU	5NTU
28	HHT-16	2.23	2.23	2.5	5NTU	5NTU
29	HHT-17	2.9	2.65	3.9	5NTU	5NTU
30	HHT-18	2.72	2.89	2.9	5NTU	5NTU
31	HHT-19	2.8	2.75	2.8	5NTU	5NTU

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

Approved By: Tafa Tolasa   Head ,Water Quality Control Service   Signature:

Table A-6 TDS result

5. Water quality test result for TDS

SN	Sample types	Result of test 1	Test 2	Ave.	WHO standard	Ethiopian standard
1	S-1	113	115	114	1000mg/l	1000mg/l
2	S-2	130	127	128.5	1000mg/l	1000mg/l
3	S-3	102	103	102.5	1000mg/l	1000mg/l
4	S-4	97	95	96	1000mg/l	1000mg/l
5	S-5	242	240	241	1000mg/l	1000mg/l
6	S-6	122	119	120.5	1000mg/l	1000mg/l
7	S-7	148	151	149.5	1000mg/l	1000mg/l
8	S-8	126	124	125	1000mg/l	1000mg/l

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

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9	S-9	157	160	158.5	1000mg/l	1000mg/l
10	R-1	139	135	137	1000mg/l	1000mg/l
11	R-2	112	110	111	1000mg/l	1000mg/l
12	R-4	155	152	153.5	1000mg/l	1000mg/l
13	HHT-1	242	240	241	1000mg/l	1000mg/l
14	HHT-2	140	137	138.5	1000mg/l	1000mg/l
15	HHT-3	102	105	103.5	1000mg/l	1000mg/l
16	HHT-4	128	125	126.5	1000mg/l	1000mg/l
17	HHT-5	107	105	106	1000mg/l	1000mg/l
18	HHT-6	116	113	114.5	1000mg/l	1000mg/l
19	HHT-7	120	118	119	1000mg/l	1000mg/l
20	HHT-8	124	127	125.5	1000mg/l	1000mg/l
21	HHT-9	132	129	130.5	1000mg/l	1000mg/l
22	HHT-10	174	173	173.5	1000mg/l	1000mg/l
23	HHT-11	145	142	143.5	1000mg/l	1000mg/l
24	HHT-12	138	135	136.5	1000mg/l	1000mg/l
25	HHT-13	127	125	126	1000mg/l	1000mg/l

Analyzed By: Rata Fikadu Date of Laboratory test: April 23-30/2018 Signature:

Approved By: Tafa Tolasa Head ,Water Quality Control Service Signature:

Table A-7 Electrical conductivity

26	HHT-14	122	119	120.5	1000mg/l	1000mg/l
27	HHT-15	130	128	129	1000mg/l	1000mg/l
28	HHT-16	146	143	144.5	1000mg/l	1000mg/l
29	HHT-17	125	122	123.5	1000mg/l	1000mg/l
30	HHT-18	109	106	107.5	1000mg/l	1000mg/l
31	HHT-19	113	111	112	1000mg/l	1000mg/l

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

Approved By: Tafa Tolasa   Head ,Water Quality Control Service   Signature:

6. Water quality test result for EC

SN	Sample types	Result of test 1 (μS/cm)	TEST2 (μS/cm)	Ave(μS/cm)	WHO standard	Ethiopian standard
1	S-1	226	230	228	2000μS/cm	2000μS/cm
2	S-2	260	254	257	2000μS/cm	2000μS/cm
3	S-3	205.7	206	205.85	2000μS/cm	2000μS/cm
4	S-4	195.5	190	192.75	2000μS/cm	2000μS/cm
5	S-5	484	480	344.4	2000μS/cm	2000μS/cm
6	S-6	244	238	241	2000μS/cm	2000μS/cm
7	S-7	296	302	299	2000μS/cm	2000μS/cm

8	S-8	252	248	250	2000µS/cm	2000µS/cm
9	S-9	314	320	317	2000µS/cm	2000µS/cm
10	R-1	278	270	274	2000µS/cm	2000µS/cm
11	R-2	224	220	222	2000µS/cm	2000µS/cm
12	R-4	310	304	307	2000µS/cm	2000µS/cm
13	HHT-1	484	480	351	2000µS/cm	2000µS/cm
14	HHT-2	280	274	277	2000µS/cm	2000µS/cm
15	HHT-3	204	210	207	2000µS/cm	2000µS/cm
16	HHT-4	256	250	253	2000µS/cm	2000µS/cm
17	HHT-5	214	210	212	2000µS/cm	2000µS/cm
18	HHT-6	232	226	229	2000µS/cm	2000µS/cm
19	HHT-7	240	236	238	2000µS/cm	2000µS/cm
20	HHT-8	248	254	251	2000µS/cm	2000µS/cm
21	HHT-9	264	258	261	2000µS/cm	2000µS/cm
22	HHT-10	348	346	347	2000µS/cm	2000µS/cm
23	HHT-11	290	284	287	2000µS/cm	2000µS/cm
24	HHT-12	276	270	273	2000µS/cm	2000µS/cm

Table A-8 Free Residual Chlorine

25	HHT-13	254	250	252	2000µS/cm	2000µS/cm
26	HHT-14	244	238	241	2000µS/cm	2000µS/cm
27	HHT-15	260	256	258	2000µS/cm	2000µS/cm
28	HHT-16	292	286	289	2000µS/cm	2000µS/cm
29	HHT-17	250	244	247	2000µS/cm	2000µS/cm
30	HHT-18	218	212	215	2000µS/cm	2000µS/cm
31	HHT-19	226	222	224	2000µS/cm	2000µS/cm

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

Approved By: Tafa Tolasa   Head ,Water Quality Control Service   Signature:

7. Water quality test result for Free Residual Chlorine

SN	Sample types	Result of test 1 and 2(mg/l)	WHO standard	Ethiópian standard
1	S-1	Nil	0.5mg/l	0.5mg/l
2	S-2	Nil	0.5mg/l	0.5mg/l
3	S-3	Nil	0.5mg/l	0.5mg/l
4	S-4	Nil	0.5mg/l	0.5mg/l
5	S-5	Nil	0.5mg/l	0.5mg/l

6	S-6	Nil	0.5mg/l	0.5mg/l
7	S-7	Nil	0.5mg/l	0.5mg/l
8	S-8	Nil	0.5mg/l	0.5mg/l
9	S-9	Nil	0.5mg/l	0.5mg/l
10	R-1	Nil	0.5mg/l	0.5mg/l
11	R-2	Nil	0.5mg/l	0.5mg/l
12	R-4	Nil	0.5mg/l	0.5mg/l
13	HHT-1	Nil	0.5mg/l	0.5mg/l
14	HHT-2	Nil	0.5mg/l	0.5mg/l
15	HHT-3	Nil	0.5mg/l	0.5mg/l
16	HHT-4	Nil	0.5mg/l	0.5mg/l
17	HHT-5	Nil	0.5mg/l	0.5mg/l
18	HHT-6	Nil	0.5mg/l	0.5mg/l
19	HHT-7	Nil	0.5mg/l	0.5mg/l
20	HHT-8	Nil	0.5mg/l	0.5mg/l
21	HHT-9	Nil	0.5mg/l	0.5mg/l
22	HHT-10	Nil	0.5mg/l	0.5mg/l
23	HHT-11	Nil	0.5mg/l	0.5mg/l
24	HHT-12	Nil	0.5mg/l	0.5mg/l
25	HHT-13	Nil	0.5m⁻/l	0.5m⁻/l

26	HHT-14	Nil	0.5mg/l	0.5mg/l
27	HHT-15	Nil	0.5mg/l	0.5mg/l
28	HHT-16	Nil	0.5mg/l	0.5mg/l
29	HHT-17	Nil	0.5mg/l	0.5mg/l
30	HHT-18	Nil	0.5mg/l	0.5mg/l
31	HHT-19	Nil	0.5mg/l	0.5mg/l

Analyzed By: Rata Fikadu   Date of Laboratory test: April 23-30/2018   Signature:

Approved By: Tafa Tolasa   Head ,Water Quality Control Service   Signature:

Appendix 2- list of questionnaire

List of Questionnaire

Questionnaire to assess customer satisfaction along the water supply service of Holeta.

Name Setlem wurkuy sex Female education status Bse date April 22/2018 ho 244

1. Do you get clean water from the pipe?	A. Yes	B. No		
2. Do you get water other than the pipe?	A. Yes	B. No		
3. Does the water supply office respond earlier for your question on maintenance?	A. Yes	B. No		
4. Do you have any water cleaner mechanism at home?	A. Yes	B. No		
5. Is that the water tariff you paid considers your capacity?	A. Yes	B. No		
6. Does your water meter work?	A. Yes	B. No		
7. How much amount of water used per day in litter?	A. less than 50litres	B. 51-100L	C. 101-500L	D. greater than 500Litres
8. How many Hours per day you get water?	A. less than 6 hours/day	B. from 7 – 12 hours/day	C. from 13 – 18 hours/day	D. greater than 19 hours/day
9. How many days after you to get response from water office?	A. less than 3 days	B. 4 – 7 days	C. More than week	

Appendix -3 population for casting

Table 3 -1 Number of Population and Area for Holeta Town 2017

No.	Kebele	Area in Hector	Total Population		
1	Goro Kerensa	722	M	F	T
	1.1 Agricultural .research	370.0			
	1.2 police station	182.8	8615.0	8967.0	17582.
	1.3 Holeta nuclas herd Ad. & Genetic improvement.	154.0			
	1.4 Agricultural. College	16			
2	Burka Harbu	410	8,748	9,105	17,853
3	Birbirsa Sibaa	538.0	4415.0	4570.0	8985.0
4	Gelgel Kuyu	1249.0	4939.0	5122.0	10061.0
5	Burqa Welmera	739.0	1556.0	1619.0	3175.0
6	Sedamo	864.0	983.0	1022.0	2005.0
7	Mada Gudina	270	835	931	1766
8	Tulu Harbu	758	847	865	1,712
Total		5550	30,938	32,201	63,139

Table 3-2 population projection by ECSA increase method

Year	n(No. of Year)	Base popn(Po)	Growth Rate(K)	Population
2017	0	63,139	0.07	63,139
2018	1	63,139	0.07	67,717
2019	2	63,139	0.07	72,627
2020	3	63,139	0.07	77,893
2021	4	63,139	0.07	83,541
2022	5	63,139	0.07	89,599
2023	6	63,139	0.07	96,095
2024	7	63,139	0.07	103,063
2025	8	63,139	0.07	110,536
2026	9	63,139	0.07	118,550
2027	10	63,139	0.07	127,146
2028	11	63,139	0.07	136,365
2029	12	63,139	0.07	146,253
2030	13	63,139	0.07	156,858
2031	14	63,139	0.07	168,231
2032	15	63,139	0.07	180,429

Appendix 4: Summarized Water Demand Calculation

Domestic Demand Calculation(DD)

Projected year		2015	2016	2017	2022	2027	2032
Growth rate (%)		4.60	4.60	4.60	4.40	4.20	4.00
Projected population		38,715	40,528	63,139	89,599	127,146	180,429
House Connected	% population	3.00%	3.80%	4.30%	5.00%	5.70%	6.30%
	Population	1161	1540	2715	4480	7247	11367
	PCD	45	45	50	50	50	60
	TPCD(l/day)	52265.3	69302.9	135748.9	223997.5	362366.1	682021.6
	TPCD(m^3/day)	52.3	69.3	135.7	224.0	362.4	682.0
Yard Connected	*% population*	11.00%	13.20%	23.40%	26.00%	28.60%	31.10%
	Population	4259	5350	14775	23296	36364	56113
	PCD	25	25	30	30	30	35.5
	TPCD(l/day)	106466.3	133742.4	443235.8	698872.2	1090912.7	1992026.4
	TPCD(m3/day)	106.5	133.7	443.2	698.9	1090.9	1992.0
Yard Shared Connected	% population	4.00%	4.30%	5.00%	7.00%	9.00%	11.00%

	Population	1549	1743	3157	6272	11443	19847
	PCD	20	20	25	25	25	27.5
	TPCD(l/day)	30972.0	34854.1	78923.8	156798.3	286078.5	545797.7
	TPCD(m3/day)	31.0	34.9	78.9	156.8	286.1	545.8
Public Tap Connected	% population	72.00%	78.70%	67.30%	62.10%	56.80%	51.60%
	Population	27875	31896	42493	55641	72219	93101
	PCD	15	15	20	20	20	22.5
	TPCD(l/day)	418122.0	478433.0	849850.9	1112819.6	1444378.6	2094780.7
	TPCD(m3/day)	418.1	478.4	849.9	1112.8	1444.4	2094.8
TDD	m^3/day	**607.8**	**716.3**	**1507.8**	**2192.5**	**3183.7**	**5314.6**

Non Domestic Demand(NDD)

Year	2015	2016	2017	2022	2027	2032
% Population	30%	30%	30%	30%	30%	30%
TDD(m^3/day)	**607.8**	**716.3**	**1507.8**	**2192.5**	**3183.7**	**5314.6**
NDD(m^3/day)	**182.3**	**214.9**	**452.3**	**657.7**	**955.1**	**1594.4**

Unaccounted For Water Demand(UWD)

Year	2015	2016	2017	2022	2027	2032
% Population	27.30%	27.20%	26.76%	26.56%	26.36%	26.16%
TDD (m3/d)	607.8	716.3	1507.8	2192.5	3183.7	5314.6
NDD (m3/d)	182.3	214.9	452.3	657.7	955.1	1594.4
UWD(m3/d)	**215.7**	**253.3**	**524.5**	**757.0**	**1091.0**	**1807.4**

Total Daily water Demand

TDWD	**1005.9**	**1184.5**	**2484.6**	**3607.3**	**5229.9**	**8716.4**

We take for the fire Demand 10% of Total demand

Fire Demand Calculation

Year	2015	2016	2017	2022	2027	2032
Total Water Demand	1005.9	1184.5	2484.6	3607.3	5229.9	8716.4

Fire Demand	**100.6**	**118.5**	**248.5**	**360.7**	**523.0**	**871.6**

Summarized Water Demand

Year	2015	2016	2017	2022	2027	2032
Projected population	38,715	40,528	63,139	89,599	127,146	180,429
TDD (m^3/d)	607.8	716.3	1507.8	2192.5	3183.7	5314.6
NDD (m3/d)	182.3	214.9	452.3	657.7	955.1	1594.4
UWD (m3/d)	215.7	253.3	524.5	757.0	1091.0	1807.4
TWD (m3/d)	1005.9	1184.5	2484.6	3607.3	5229.9	8716.4
Socio-economic factor	1	1	1	1	1	1
Climatic Factor	1	1	1	1	1	1
Adjested TD (m3/d)	1005.9	1184.5	2484.6	3607.3	5229.9	8716.4
Adjusted TD (l/day)	1005880.7	1184527.3	2484606.4	3607255.9	5229859.2	8716412.5
MDF	1.3	1.3	1.3	1.3	1.3	1.3
MDD (m3/d)	1307.6	1539.9	3230.0	4689.4	6798.8	11331.3
MDD (l/day)	1307644.9	1539885.4	3229988.4	4689432.6	6798816.9	11331336.2
MDD (l/sec)	15.1	17.8	37.4	54.3	78.7	131.1
PHF	1.8	1.8	1.8	1.8	1.8	1.8

PHD (m3/d)	1810.6	2132.1	4472.3	6493.1	9413.7	16561.2
PHD (l/day)	1810585.2	2132149.1	4472291.6	6493060.6	9413746.5	16561183.7

Table 4-1 Number Of Public Tab Of Holeta Water Supply System

No.	Year	Number of public tab	Way of supply	Remark
1	2012	34	Two taps on two ways	Functional
2	2013	38	Two taps on two ways	Two is not functional
3	2014	42	Two taps on two ways	Two is not functional
4	2015	44	Only three is Three taps on two ways	Two is not functional
5	2016	49	Only five is Three taps on two ways	three is not functional
6	2017	51	Only five is Three taps on two ways	three is not functional

Table 4-2 Existing Tariff Rates of Holeta Town Water Supply Service. Which Is Studied 2017

Services	Range cons.(m3)	Tariff in Birr
1st band	0-2m3	Birr 4.00
2nd band	3-5m3	Birr 5.50
3rd band	6-10m3	Birr 6.50
4th band	>11m3	Birr 7.20

Table 4-3 Current Tariff Rates of Holeta Town Water Supply Service. Which Is Studied Sept .2016

Services	Range cons.(m3)	Tariff in Birr
1st band	0-3m3	Birr 7.80
2nd band	4-6m3	Birr 8.85
3rd band	7-9m3	Birr 9.35
4th band	10-12m3	Birr 11.20
5th band	>12m3	Birr 13.45

Appendix 5 Water Production

Table 5-1 Monthly Water Production from Existing Sources In 2012

No	name of Source	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1	BH1	1200	599	805	812	2642	1086	430	873	1008	489	2000		11944
2	BH2	1,100	1,715	1,800	741	1,074	1,500	2,500	1,952	1,679	1,519	800	1,100	17,480
3	BH3	2,080	3,008		1,000	2,018	2,026	3,089	3,081	807	3,100	3,018	798	24,025
4	BH4	903			2,357	3,049	1,811	1,985	742	800	789	320		12,756
5	BH5	6,892	5,049	4,022	5,204	3,849	4,505	3,512	4,900	6,120	5,471	4,158	4,018	57,700
6	BH6	1,020	802	645	708	1,550	458	780	2,017	189	781	2,041	799	11,790
7	BH7	6,014	5,017	3,078	908	6,418	5,900	7,800	7,800	4,104	8,780	8,008	9,013	72,840
8	BH8	3,099	2,582	3,560	2,894	3,481	4,125	2,614	2,844	4,180	3,612	687	5,012	38,690
9	BH9		2,014	2,101	4,012	2,000	2,415	1,018	2,016		3,012	3,047	880	22,515
	Total	22,308	20,786	16,011	18,636	26,081	23,826	23,728	26,225	18,887	27,553	24,079	21,620	269,740

Table 5-2 Monthly Water Production from Existing Sources In 2013

No	name of S	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total(m3)
1	BH-1	579		517	810	982	872						1,008	4,768
2	BH2	1,670	457	855	744	568	715	145	879		1,025	578	644	8,280
3	BH3		1,014	3,158			1,078	297	2,587	1,078	803	458	2,547	13,020
4	BH4	1,105						1,068	1,014	305	218		0	3,710
5	BH5	5,001	4,018	3,018	4,017	1,000		4,789	4,859	3,000	3,331	2,878	4,789	40,700
6	BH6	304	879	985	478	789	1,065							4,500
7	BH7	5,704	7,801	5,891		5,700	5,934	4,014	6,751	5,894	7,093	3,879	2,089	60,750
8	BH8	1,000	2,020	3,045	4,018	548	3,709	2,018	458	127	2,017	874	600	20,434
9	BH9			1,700	514	1,013	1,025	1,014	800	839	207	5,877	1,478	14,467
10	BH10	1,014	3,085	1,478	4,458	4,018	785	1,864	1,891	3,598	4,487	5,879	2,015	34,572
Total		16,37	19,274	20,647	15,039	14,618	15,183	15,209	19,239	14,841	19,181	20,423	15,170	205,201

Table 5-3 Monthly Water Production from Existing Sources In 2014

No	name of Source	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total(m3)
1	BH1				1,401	2,017	310	367	362					4,457
2	BH2				608	784	788	489	1,916	714	1,089	982		7,370
3	BH3	1,047	708	1,149	258	487	2,018	787	894	1,148	1,682	1,834	1,000	13,012
4	BH4									1,148	2,004	488		3,640
5	BH5	4,018	2,047	847	2,019	568	4,896	4,785	3,258	4,881	3,414	3,847	4,000	38,580
6	BH6	1,045	905	768										2,718
7	BH7	6,487	4,879	5,254	4,856	6,578	5,847	3,487	5,278	4,857	4,896	3,785	3,493	59,697
8	BH8	2,013	2,087	2,587	2,073	401	589	2,147	2,587	1,637	2,587	1,433	1,098	21,239
9	BH9	1,484	521	801	783	1,390	785	2,014	2,015	2,087	1,000		587	13,467
10	BH10	2,482	2,879	3,518	4,021	1,845	2,357	1,863	2,849	2,017	2,894	2,538	4,189	33,452
Total		18,576	14,026	14,924	16,019	14,070	17,590	15,939	19,159	18,489	19,566	14,907	14,367	197,632

Table 5-4 Monthly Water Production from Existing Sources In 2015

No	name of source	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total(m3)
1	BH1	870	876	1,028	2,014	871	896		1,204	1,607		2,084		11,450
2	BH2	1,847	1,600	1,011	1,897	1,579	1,582	1,480	1,487	1,835	1,096	480	1,390	17,284
3	BH3	1,780	1,204	1,681	1,682	1,466	1,549	1,920	2,084	1,514	1,478	2,037	2,027	20,422
4	BH4	1,014	810	1,250	489	1,780	1,018	423	879	1,963	1,548	1,527		12,701
5	BH5	5,871	4,896	4,576	5,864	5,804	5,847	4,587	4,695		5,247	5,369	4,895	57,651
6	BH6													
7	BH7	5,470	5,482	6,487	6,482	6,574	6,654	6,584	6,441	6,579	6,487	5,387	4,121	72,748
8	BH8	2,017	2,180	2,050	3,154	2,018	2,548	569	2,478	2,785	2,957	2,879	4,018	29,653
9	BH9	1,014	1,870	1,473	475	2,168	2,475	1,980	3,000	2,009	2,013	2,098	1,825	22,400
10	BH10					1,854	2,570	1,438		1,381	1,957	1,380		10,580
Total		19,883	18,918	19,556	22,057	24,114	25,139	18,981	22,268	19,673	22,783	23,241	18,276	254,889

Table 5-5 Monthly Water Production from Existing Sources In 2016

No	name of	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total(m3)
1	BH1	835	925	2085	1247			2045	1497		977	2897	0	12508
2	BH2	2,080	1,709	1,079	381		2,148	1,481	1,724	319	2,807	1,982	1,728	17,438
3	BH3	3,087	2,187	2,547	1,728	1,893	2,879	2,018	1,835	2,405	1,896	1,879	2,187	26,541
4	BH4	1,160	874	947	2,017					1,879	2,473	1,875	2,157	13,382
5	BH5	4,872	4,725	4,201	4,287	6,046	4,578	4,879	5,798	5,147	5,492	4,079	5,147	59,251
6	BH6													
7	BH7	5,802	5,720	6,208	7,207	5,259	4,370	6,872	6,081	6,107	6,440	6,500	5,872	72,438
8	BH8	2,780	2,981	3,021	1,978	3,872	5,125	2,570	2,516	3,578	4,500	3,091	3,537	39,549
9	BH9	2,043	2,873	1,170	2,145	3,148			3,018	3,112	2,017	3,874	0	23,400
10	BH10	1,008	1,873	1,088	1,475	1,477	1,547	1,188	1,108	1,481	0	0	0	12,245
Total		23,667	23,867	22,346	22,465	21,695	20,647	21,053	23,577	24,028	26,602	26,177	20,628	276,752

Table 5-6 Monthly Water Production from Existing Sources In 2017

No.	Name of source	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annually
1	BH1	1,879	1,521	2,087	1,503	3,287	1,914	4,012		2,200	1,498	1,408	1,625	22,934
2	BH 2	2,420	2,877	2,950	1,501	3,269	4,681		1,694	2,185	2,819	1,473	1,982	27,851
3	BH 3	4,002	4,058	3,589	5,879	4,000	3,547	1,511	2,571	3,108	3,326	2,033	4,864	42,488
4	BH 4	4,378	2,863	2,487	2,050	8,318			2,524	4,656	2,111	2,855	4,392	36,634
5	BH 5	6,160	8,945	8,948	8,500	1,642		2,575	1,529	8,300	8,372	9,814	8,740	73,525
6	BH 6													
7	BH7	8,521	10,054	8,203	8,054	8,256	9,528	2,159		10,023	11,085	12,080	9,875	97,838
8	BH 8	5,423	4,345	4,916	9,253	14,291	10,598	2,471	1,498	6,954	5,412	5,478	5,129	75,768
9	BH 9	7,014	4,058	5,116	9,873	4,333	7,357	1,426	3,175	3,125	3,067	3,077	3,217	54,838
10	BH 10	3,457	568	2,355	8,711	8,665	8,907		1,851	2,018	1,263	4,567	2,514	44,876
Total		43,254	39,289	40,651	55,324	56,061	46,532	14,154	14,842	42,569	38,953	42,785	42,338	476,752

APPENDIX 6 Water Consumption

Table 6-1 Monthly Water Consumption for the Year 2012

Month	No of Costumers	consumption in m3	consumption paid(Birr)
January	3,408	18,800	177,410
February	3,441	18,905	177,214
March	3,466	18,997	178,097
April	3,389	18,969	177,147
May	3,466	18,924	177,854
June	3,442	18,558	177,365
July	3,463	19,110	177,478
August	3,466	18,685	177,987
September	3,466	18,490	177,140
October	3,465	18,596	177,500
November	3,463	17,944	177,536
December	3,463	18,247	177,490
Total=3,466		224,225	2,130,218

Table 6-2 Monthly Water Consumption for The 2013

Month	No of Costumers	consumption in m3	consumption paid(Birr)
January	4,100	14,008	278,500
February	4,104	14,204	278,150
March	4,106	14,042	278,754
April	4,106	14,173	278,325
May	4,106	14,150	278,844
June	4,105	14,012	278,804
July	4,106	13,140	278,692
August	4,106	14,554	278,387
September	3,905	14,015	278,602
October	4,100	14,154	278,754
November	4,102	14,895	278,635
December	4,106	14,970	278,706
Total=4106		170,317	3,343,153

Table 6-3 Monthly Water Consumption for the Year 2014

Month	No of Costumers	consumption in m3	consumption paid(Birr)
January	4,769	13,800	403,800
February	4,760	13,752	403,712
March	4,764	14,596	403,587
April	4,768	13,458	404,476
May	4,769	13,995	403,618
June	4,700	13,745	403,891
July	4,767	13,238	404,753
August	4,759	13,875	403,940
September	4,765	13,864	403,211
October	475	13,838	403,680
November	4,700	13,876	403,610
December	4,744	13,798	403,780
Total =4769		165,835	4,846,058

Table 6-4 Monthly Water Consumption for the Year 2015

Month	No of Costumers	consumption in m3	consumption paid(Birr)
January	5368	17,106	316,909
February	5355	17,118	316,800
March	5376	17,113	316,948
April	5378	17,100	317,405
May	5378	17,098	317,868
June	5378	17,300	316,870.94
July	5377	17,204	316,986
August	5374	17,152	316,478
September	5354	17,269	316,654
October	5376	17,012	316,894
November	5378	17,104	316,890
December	5378	17,874	317,290
Total =5378		206,450	3,803,992.94

Table 6-5 Monthly Water Consumption for the Year 2016

Month	No of Costumers	consumption in m3	consumption paid(Birr)
January	5,890	19,749	340,652
February	5,888	20,280	340,640
March	5,875	19,583	340,514
April	5,893	19,754	340,972.24
May	5,893	20,918	340,564
June	5,893	19,290	340,424
July	5,785	19,594	340,984
August	5,893	19,477	340,461
September	5,893	19,658	340,921
October	5,889	19,578	340,697
November	5,893	19,511	340,200
December	5,893	19,688	340,487
Total =5,893		237,080	4,087,516.24

Table 6-6 Monthly Water Consumption for the Year 2017

Month	No of Costumers	consumption in (m3)	consumption paid(Birr)
January	6,791	40,510	595182
February	6,788	35,884	596152
March	6,780	37,171	593924
April	6,740	45,550.00	589097
May	6,782	42,861	599041
June	6,775	37,361	599254
July	6,752	10,407	381270
August	6,703	13,344	350841
September	6,710	38,957	444147
October	6,745	38,038	410900
November		38,561	431384
December	6,791	36,849	371674
Total = 6791		415,493.00	5962866

Appendix 7 customer Respondent

Table 7-1 Response on Water Pressure from Pipe

No.	customers interviewed	Total customers	Do you get water with enough pressure?			
			yes	No	miss	Percentage of respond
1.	private residence	250	120	5	125	50%
2	Institutional	10	3	----	7	30%
3.	Commercial	115	82	22	8	90.43%
4.	Industrial	5	3	1	1	80%

Table 7-2 Response On Maintenance Request.

No.	customers interviewed	Total customers	Does the water supply office respond earlier for your question on Maintenance?			
			yes	No	Miss	Percentage of respond
1.	private resedence	250	110	90	50	80%
2	Institutional	10	1	4	5	50%
3.	Commercial	115	85	3	27	76.52%
4.	Industrial	5	2	1	2	60%

Table 7-3 Response on Cleanness of Water

No.	customers interviewed	Total customers	Do you get clean water from the pipe?				
			yes	No	It depends on the season	Miss	Percentage of respond
1.	private residence	250	130	2	8	110	56%
2	Institutional	10	2	5	1	2	70%
3.	Commercial	115	88	1	12	14	87.8%
4.	Industrial	5	2	----	1	1	60%

Table 7-4 Response on Home Water Treatment Method

No.	customers interviewed	Total customers	Do you have any water cleaner mechanism at home?			
			yes	No	Miss	Percentage of respond
1.	private residence	250	---	102	148	40.8%
2	Institutional	10	---	7	3	70%
3.	Commercial	115	---	98	17	85.22%
4.	Industry	5	---	2	3	40%

Table 7-5 Response on Water Tariff

No.	customers interviewed	Total customers	Is that the water tariff you paid considers your capacity			
			yes	No	Miss	Percentage of respond
1.	private residence	250	--	200	50	80%
2	Institutional	10	4	----	6	40%
3.	Commercial	115	----	95	20	82.60%
4.	Industry	5	---	4	1	80%

Table 7-6 Response on Functionality of Water Meter

No.	customers interviewed	Total customers	Does your water meter work?			
			yes	No	Miss	Percentage of respond
1.	private residence	250	130	---	20	52%
2	Institutional	10	4	---	6	40%
3.	Commercial	115	98	----		85.22%
4.	Industry	5	4	----	1	80%

Table 7-7 Response on Water Consumption

No.	customers interviewed	Total customers	How much amount of water used per day in litter?					
			less than 50litres	51-100L	101-500L	greater than 500L	missed or no response	Percentage of respond
1.	private residence	250	122	---	---	---	128	48.8%
2	Institutional	10	7	----	----	-----	3	70%
3.	Commercial	115	----	38	50	----	27	76.52%
4.	Industry	5	----	---	---	4	1	80%

Table 7-8 Response on Availability of Water

No.	customers interviewed	Total customers	How many Hours per day you get water?					
			less than 6 hours/ day	from 7 – 12 hours/day	form 13 – 18 hours/day	greater than 19 hours/day	missed or no response	Percentage of respond
1.	private resedence	250	6	100	3	2	139	44.4%
2	Institutional	10	40	2	----	----	8	84%
3.	Commercial	115	4	----	----	----	6	40%
4.	Industry	5	------	4	1	-----	------	100%

Table 7-9 Response for Days Elapsed To Get Maintenance Request Replied

No.	customers interviewed	Total customers	How many days after you get response from water supply office?				
			less than 3 days	4 – 7 days	More than week	missed or no response	Percentage of respond
1.	private residence	250	102	5	8	135	46%
2	Institutional	10	3	--	---	7	30%
3.	Commercial	115	104	3		8	93%
4.	Industry	5	3	1		1	80%

APPENDIX 8- Water GEMS Simulation Result

Table 8-1 Pipe Report Run By GEMS @ 7:00AM

ID	Label	Elevation (m)	Zone	Demand Collection	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
39	J-1	2,393.00	<None>	<Collection: 1 item>	0.08	2,420.49	31
43	J-2	2,362.00	<None>	<Collection: 1 item>	0.08	2,420.40	58
44	J-3	2,354.00	<None>	<Collection: 1 item>	0.07	2,420.38	66
64	J-19	2,337.00	<None>	<Collection: 1 item>	0.04	2,418.93	82
67	J-22	2,336.00	<None>	<Collection: 1 item>	0.07	2,418.94	83
75	J-29	2,342.00	<None>	<Collection: 1 item>	0.05	2,418.95	77
76	J-30	2,340.00	<None>	<Collection: 1 item>	0.07	2,418.94	79
81	J-35	2,339.00	<None>	<Collection: 1 item>	0.05	2,392.20	53
101	J-36	2,339.00	<None>	<Collection: 1 item>	0.09	2,408.26	69
102	J-37	2,336.00	<None>	<Collection: 1 item>	0.07	2,420.20	87
107	J-38	2,336.00	<None>	<Collection: 1 item>	0.09	2,392.49	56
109	J-39	2,337.00	<None>	<Collection: 1 item>	0.08	2,392.48	55
110	J-40	2,337.00	<None>	<Collection: 1 item>	0.08	2,406.18	69

113	J-43	2,334.00	<None>	<Collection: 1 item>	0.07	2,392.48	58
114	J-44	2,336.00	<None>	<Collection: 1 item>	0.09	2,392.48	56
169	J-50	2,348.00	<None>	<Collection: 1 item>	0.09	2,418.51	70
176	J-51	2,346.00	<None>	<Collection: 1 item>	0.09	2,409.48	63
243	J-55	2,333.00	<None>	<Collection: 1 item>	0.08	2,418.96	86
246	J-56	2,333.00	<None>	<Collection: 1 item>	0.35	2,418.97	86
258	J-57	2,324.00	<None>	<Collection: 1 item>	0.07	2,420.70	100
291	J-62	2,335.00	<None>	<Collection: 1 item>	0.55	2,411.53	76
371	J-140	2,351.00	<None>	<Collection: 1 item>	0.01	2,402.89	52
375	J-142	2,359.89	<None>	<Collection: 1 item>	0.06	2,416.91	57
380	J-144	2,355.67	<None>	<Collection: 1 item>	0.04	2,402.39	47
385	J-146	2,335.86	<None>	<Collection: 1 item>	0.04	2,392.21	56
388	J-147	2,332.00	<None>	<Collection: 1 item>	0.04	2,392.22	60
390	J-148	2,353.48	<None>	<Collection: 1 item>	0.08	2,402.22	49
393	J-149	2,334.00	<None>	<Collection: 1 item>	0.09	2,397.00	63
395	J-150	2,338.00	<None>	<Collection: 1 item>	0.09	2,397.35	59
399	J-151	2,354.00	<None>	<Collection: 1 item>	0.09	2,397.45	37

401	J-152	2,341.00	<None>	<Collection: 1 item>	0.07	2,396.70	56
403	J-153	2,341.00	<None>	<Collection: 1 item>	0.09	2,401.64	61
405	J-154	2,336.33	<None>	<Collection: 1 item>	0.09	2,392.45	56
408	J-155	2,336.00	<None>	<Collection: 1 item>	0.25	2,393.24	57
410	J-156	2,330.00	<None>	<Collection: 1 item>	0.18	2,392.79	63
412	J-157	2,331.00	<None>	<Collection: 1 item>	0.37	2,392.67	54
414	J-158	2,331.00	<None>	<Collection: 1 item>	0.09	2,394.20	63
416	J-159	2,331.00	<None>	<Collection: 1 item>	0.04	2,397.26	66
418	J-160	2,328.00	<None>	<Collection: 1 item>	0.08	2,392.77	65
420	J-161	2,335.00	<None>	<Collection: 1 item>	0.04	2,393.73	59
422	J-162	2,335.00	<None>	<Collection: 1 item>	0.01	2,392.53	57
424	J-163	2,329.00	<None>	<Collection: 1 item>	0.08	2,392.39	63
426	J-164	2,331.00	<None>	<Collection: 1 item>	0.09	2,392.28	61
428	J-165	2,334.00	<None>	<Collection: 1 item>	0.05	2,393.18	51
431	J-166	2,331.00	<None>	<Collection: 1 item>	0.08	2,393.16	62
433	J-167	2,330.00	<None>	<Collection: 1 item>	0.09	2,395.80	66
435	J-168	2,335.00	<None>	<Collection: 1 item>	0.09	2,414.02	79

437	J-169	2,329.00	<None>	<Collection: 1 item>	0.08	2,401.52	72
439	J-170	2,328.00	<None>	<Collection: 1 item>	0.04	2,397.30	69
441	J-171	2,330.00	<None>	<Collection: 1 item>	0.07	2,397.23	67
448	J-173	2,328.00	<None>	<Collection: 1 item>	0.09	2,397.23	63
450	J-174	2,328.00	<None>	<Collection: 1 item>	0.08	2,397.22	69
452	J-175	2,332.00	<None>	<Collection: 1 item>	0.08	2,397.23	65
455	J-176	2,334.00	<None>	<Collection: 1 item>	0.08	2,397.23	63
458	J-177	2,328.00	<None>	<Collection: 1 item>	0.08	2,396.48	68
461	J-178	2,328.00	<None>	<Collection: 1 item>	0.08	2,397.24	69
463	J-179	2,343.82	<None>	<Collection: 1 item>	0.07	2,396.85	53
467	J-180	2,349.08	<None>	<Collection: 1 item>	0.09	2,403.33	58
471	J-181	2,336.91	<None>	<Collection: 1 item>	0.08	2,392.37	55
474	J-182	2,334.35	<None>	<Collection: 1 item>	0.1	2,392.23	50

Table 8-2 Report from GEMS Comparison Of Velocity And Discharge

ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Loss Coefficient (Local)	Flow (L/s)	Velocity (m/s)
127	P-1	439	J-1	J-2	200	HDPE	130	FALSE	0	5.51	0.18
128	P-2	47	J-2	J-3	150	HDPE	130	FALSE	0	3.24	0.18
148	P-12	31	J-29	J-30	50	Galvanized iron	120	FALSE	0	0.18	0.09
178	P-15	50	J-51	J-36	50	Galvanized iron	120	FALSE	0	1.71	0.87
191	P-16	179	J-39	J-43	100	Galvanized iron	120	FALSE	0	0.07	0.01
192	P-17	230	J-39	J-38	100	Galvanized iron	120	FALSE	0	-0.15	0.02
193	P-18	83	J-38	J-44	100	Galvanized iron	120	FALSE	0	0.25	0.03
210	P-29	72	J-22	J-19	50	HDPE	130	FALSE	0	0.04	0.02
245	P-35	19	J-55	J-29	50	HDPE	130	FALSE	0	0.23	0.12

247	P-36	487	J-37	J-56	100	Galvanized iron	120	FALSE	0	3.1	0.39
248	P-37	284	J-56	J-50	100	Galvanized iron	120	FALSE	0	2.44	0.31
249	P-38	59	J-55	J-56	75	Galvanized iron	120	FALSE	0	-0.31	0.07
259	P-39	381	J-57	T-3	150	Galvanized iron	120	FALSE	0	3.88	0.22
292	P-51	183	J-50	J-62	50	HDPE	130	FALSE	0	2.35	1.2
293	P-52	76	J-62	J-51	50	Galvanized iron	120	FALSE	0	1.8	0.92
307	P-56	68	J-3	J-37	100	Galvanized iron	120	FALSE	0	3.17	0.4
336	P-66	84	J-57	PMP-2	150	Galvanized iron	120	FALSE	0	-3.95	0.22
337	P-67	17	R-2	PMP-2	150	Galvanized iron	120	FALSE	0	3.95	0.22
343	P-68	19	R-3	PMP-3	150	Galvanized iron	120	FALSE	0	5.19	0.29
344	P-69	337	PMP-3	T-3	150	Galvanized iron	120	FALSE	0	5.19	0.29

356	P-71	674	J-36	J-40	75	Galvanized iron	120	FALSE	0	1.62	0.37
361	P-72	44	J-30	J-22	50	Galvanized iron	120	FALSE	0	0.11	0.06
365	P-73	282	J-1	T-3	300	Galvanized iron	120	FALSE	0	-5.59	0.08
376	P-182	90	J-2	J-142	50	Galvanized iron	120	FALSE	0	2.19	1.12
381	P-185	1,247	J-142	J-144	50	HDPE	130	FALSE	0	1.24	0.63
387	P-189	210	J-146	J-35	50	Galvanized iron	120	FALSE	0	0.05	0.03
391	P-191	91	J-144	J-148	50	Galvanized iron	120	FALSE	0	0.43	0.22
392	P-192	364	J-148	J-140	50	Galvanized iron	120	FALSE	0	-0.42	0.22
396	P-194	866	J-148	J-150	50	Galvanized iron	120	FALSE	0	0.77	0.39
397	P-195	192	J-150	J-149	50	Galvanized iron	120	FALSE	0	0.42	0.21
398	P-196	192	J-149	J-150	50	Galvanized iron	120	FALSE	0	-0.42	0.21

400	P-197	304	J-150	J-151	50	Galvanized iron	120	FALSE	0	-0.16	0.08
404	P-199	155	J-144	J-153	50	HDPE	130	FALSE	0	0.77	0.39
406	P-200	123	J-44	J-154	50	HDPE	130	FALSE	0	0.16	0.08
409	P-202	1,485	J-154	J-155	50	HDPE	130	FALSE	0	-0.23	0.12
411	P-203	270	J-155	J-156	50	HDPE	130	FALSE	0	0.43	0.22
413	P-204	428	J-156	J-157	50	HDPE	130	FALSE	0	0.17	0.09
417	P-206	873	J-158	J-159	50	Galvanized iron	120	FALSE	0	-0.6	0.3
419	P-207	324	J-156	J-160	50	Galvanized iron	120	FALSE	0	0.08	0.04
421	P-208	64	J-155	J-161	50	Galvanized iron	120	FALSE	0	-0.92	0.47
423	P-209	363	J-157	J-162	50	Galvanized iron	120	FALSE	0	0.18	0.09
425	P-210	389	J-162	J-163	50	Galvanized iron	120	FALSE	0	0.17	0.09
427	P-211	1,066	J-163	J-164	50	Galvanized iron	120	FALSE	0	0.09	0.05
429	P-212	341	J-157	J-165	50	Galvanized	120	FALSE	0	-0.38	0.19

						iron					
430	P-213	392	J-165	J-158	50	Galvanized iron	120	FALSE	0	-0.51	0.26
432	P-214	218	J-165	J-166	50	Galvanized iron	120	FALSE	0	0.08	0.04
434	P-215	1,340	J-38	J-167	50	Galvanized iron	120	FALSE	0	-0.49	0.25
436	P-216	390	J-142	J-168	50	Galvanized iron	120	FALSE	0	0.89	0.46
438	P-217	2,057	J-168	J-169	50	Galvanized iron	120	FALSE	0	0.8	0.41
440	P-218	843	J-169	J-170	50	Galvanized iron	120	FALSE	0	0.72	0.37
442	P-219	92	J-170	J-171	50	Galvanized iron	120	FALSE	0	0.26	0.13
445	P-221	943	J-153	J-151	50	Galvanized iron	120	FALSE	0	0.68	0.35
446	P-222	687	J-151	J-159	75	Galvanized iron	120	FALSE	0	0.43	0.1
447	P-223	295	J-159	J-170	75	Galvanized iron	120	FALSE	0	-0.28	0.06

449	P-224	320	J-170	J-173	50	Galvanized iron	120	FALSE	0	0.14	0.07
451	P-225	96	J-173	J-174	50	Galvanized iron	120	FALSE	0	0.05	0.02
453	P-226	316	J-174	J-175	50	Galvanized iron	120	FALSE	0	-0.03	0.02
454	P-227	25	J-175	J-171	75	Galvanized iron	120	FALSE	0	-0.19	0.04
456	P-228	136	J-175	J-176	75	Galvanized iron	120	FALSE	0	0.08	0.02
457	P-229	413	J-149	J-152	75	Galvanized iron	120	FALSE	0	0.75	0.17
459	P-230	164	J-152	J-177	75	Galvanized iron	120	FALSE	0	1.04	0.23
460	P-231	328	J-177	J-161	50	Galvanized iron	120	FALSE	0	0.96	0.49
462	P-232	303	J-159	J-178	50	Galvanized iron	120	FALSE	0	0.08	0.04
465	P-234	114	J-179	J-152	50	Galvanized iron	120	FALSE	0	0.36	0.18
466	P-235	364	J-167	J-179	50	Galvanized iron	130	FALSE	0	-0.58	0.3

468	P-236	224	J-140	J-180	50	Galvanized iron	120	FALSE	0	-0.43	0.22
469	P-237	696	J-180	J-179	50	Galvanized iron	120	FALSE	0	1.01	0.52
470	P-238	164	J-40	J-180	50	Galvanized iron	130	FALSE	0	1.54	0.78
472	P-239	93	J-154	J-181	50	HDPE	130	FALSE	0	0.31	0.16
475	P-241	172	J-146	J-182	50	Galvanized iron	120	FALSE	0	-0.09	0.05
476	P-242	216	J-182	J-147	50	Galvanized iron	120	FALSE	0	0.04	0.02
477	P-243	240	J-181	J-182	50	Galvanized iron	120	FALSE	0	0.23	0.11

Table 8-3 Calculated

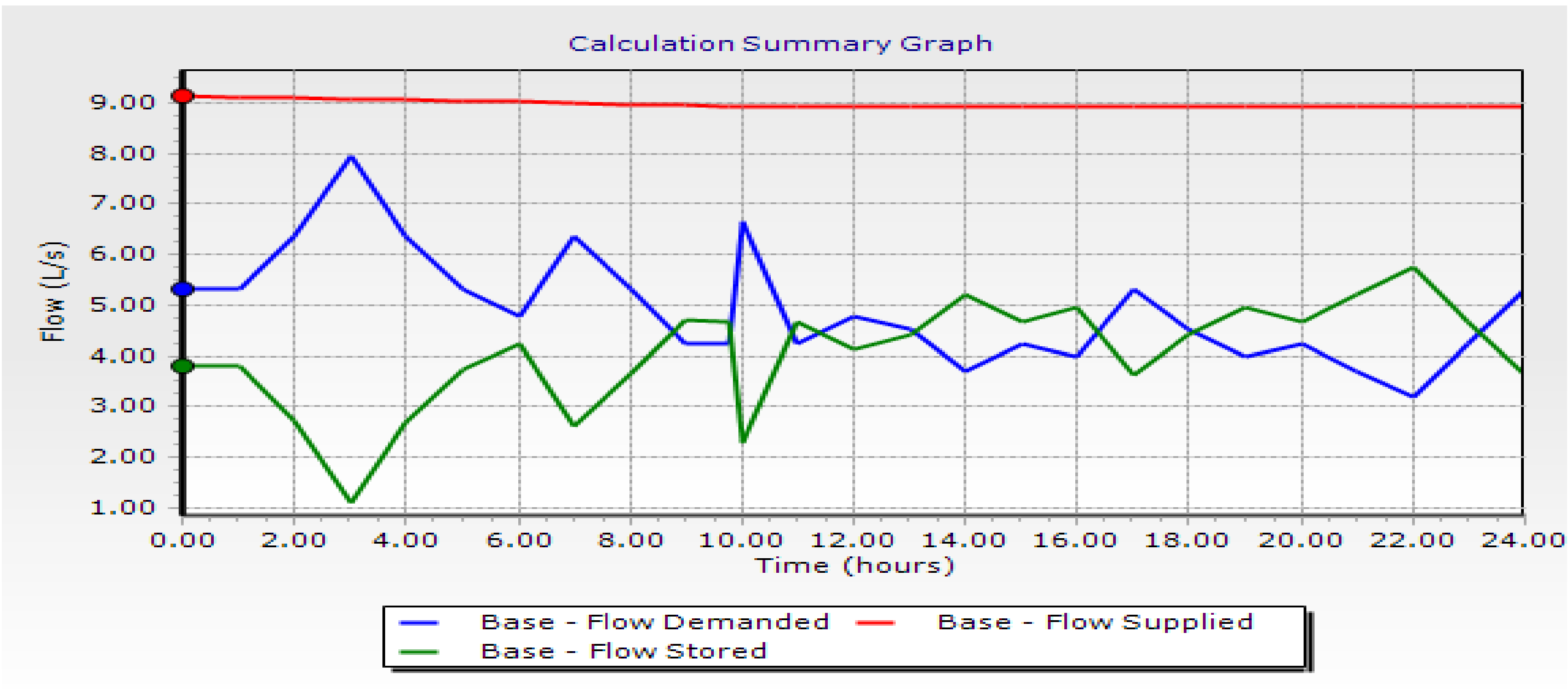
Summary Report

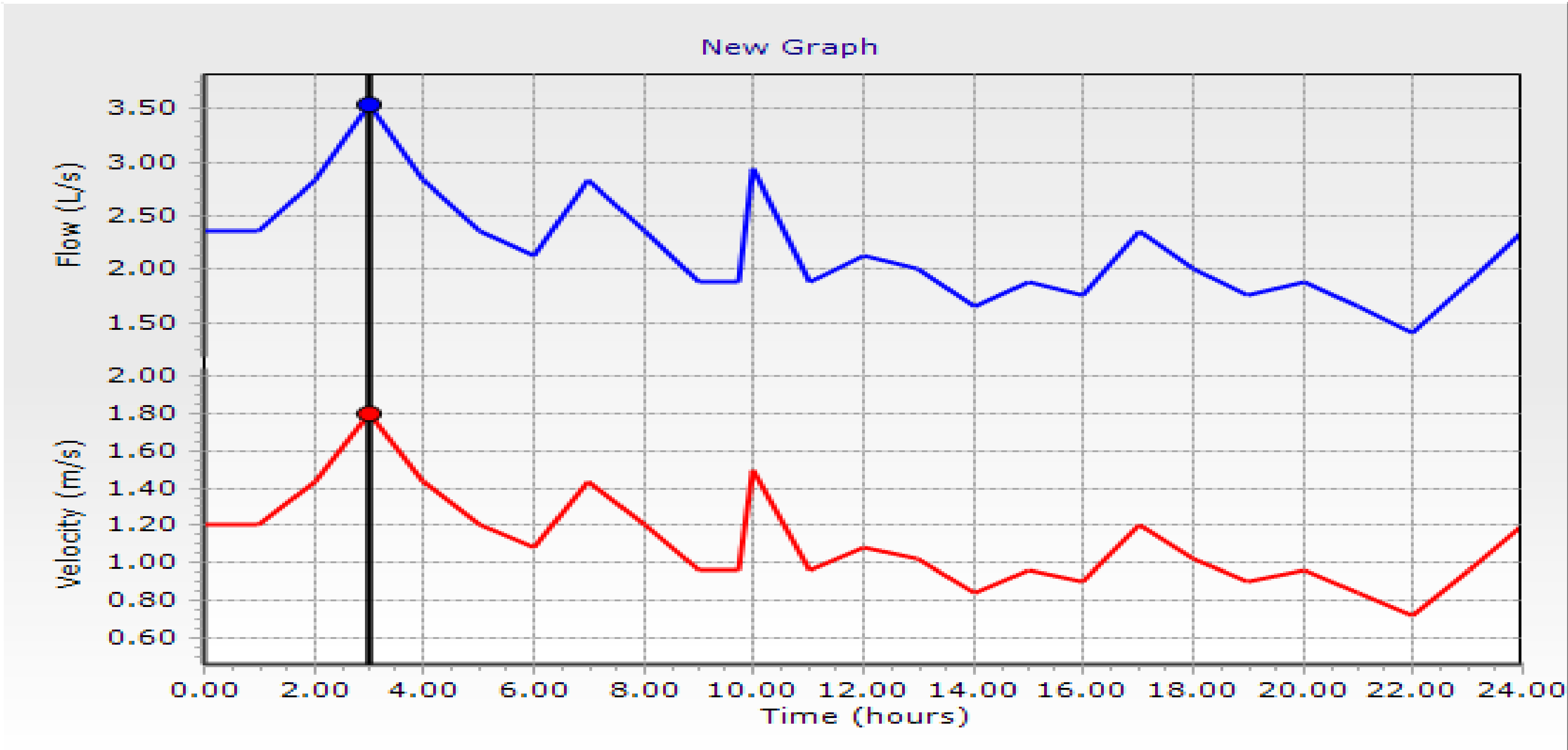
Calculation Summary (1: Base)

Time (hours)	Balanced?	Trials	Relative Flow Change	Flow Supplied (L/s)	Flow Demanded (L/s)	Flow Stored (L/s)
All Time Steps(25)	True	54	0.0004855	8.97	4.93	4.04
0.00	True	4	0.0004855	9.14	5.31	3.82
1.00	True	2	0.0000019	9.11	5.31	3.80
2.00	True	2	0.0000017	9.09	6.37	2.71
3.00	True	2	0.0000008	9.07	7.97	1.10
4.00	True	2	0.0000002	9.06	6.37	2.69
5.00	True	2	0.0000010	9.04	5.31	3.73
6.00	True	2	0.0000020	9.02	4.78	4.24
7.00	True	2	0.0000022	8.99	6.37	2.62
8.00	True	2	0.0000010	8.98	5.31	3.66
9.00	True	2	0.0000021	8.95	4.25	4.70
9.75	True	2	0.0000020	8.93	4.25	4.68
10.00	True	2	0.0000000	8.93	6.64	2.29
11.00	True	2	0.0000000	8.93	4.25	4.68
12.00	True	2	0.0000000	8.93	4.78	4.15
13.00	True	2	0.0000001	8.93	4.52	4.41
14.00	True	2	0.0000000	8.93	3.72	5.21
15.00	True	2	0.0000000	8.93	4.25	4.68
16.00	True	2	0.0000000	8.93	3.98	4.94
17.00	True	2	0.0000000	8.93		
18.00	True	2	0.0000000	8.93		
19.00	True	2	0.0000000	8.93		
20.00	True	2	0.0000000	8.93		
21.00	True	2	0.0000000	8.93		
22.00	True	2	0.0000000	8.93		
23.00	True	2	0.0000000	8.93		
24.00	True	2	0.0000000	8.93		

Calculation Summary (1: Base)

Flow Demanded (L/s)	Flow Stored (L/s)
5.31	3.62
4.52	4.41
3.98	4.94
4.25	4.68
3.72	5.21
3.19	5.74
4.25	4.68
5.31	3.62




New Graph
Flow (L/s)
3.50
3.00
2.50
2.00
1.50
Velocity (m/s)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.00 2.00 4.00 6.00 8.00 10.00 12.00 14.00 16.00 18.00 20.00 22.00 24.00
Time (hours)

Appendix 9- Total Water production, Consumption and Losses

Table 9-1 Monthly Total Water Production, Consumption and Loss for the Year 2012

No	type	January	February	March	April	May	June	July	August	September	October	November	December	Average
1	water	22080	23054	21091	19894	23543	22308	23645	20318	24158	23618	23548	22483	22478.
2	water	18800	18905	18997	18969	18924	18558	19110	18685	18490	18596	17944	18247	18685.
3	water loss	3280	4149	2094	925	4619	3750	4535	1633	5668	5022	5604	4236	3792.9
4	water loss in %	14.85	17.996	9.928	4.649	19.61	16.81	19.17	8.037	23.4622	21.26	23.7982	18.8409	16.536

Table 9-2 Monthly Total Water Production, Consumption and Loss for the Year 2013

No.	Type	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
1	water production	16377	19274	20647	15039	14618	15183	15209	19239	14841	19181	20423	15170	17100.1
2	water , consumption	14,008	14,204	14,042	14,173	14,150	14,012	13,140	14,554	14,015	14,154	14,895	14,970	14,193
3	water loss	2,369	5,070	6,605	866	468	1,171	2,069	4,685	826	5,027	5,528	200	2,907
4	water loss in %	14.465	26.304	31.99	5.758	3.201	7.712	13.603	24.351	5.565	26.208	27.067	1.318	15.6285

Table 9-3 Monthly Total Water Production, Consumption and Loss for the Year 2014

No.	Type	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
1	water production	18576	14026	14924	16019	14070	17590	15939	19159	18489	19566	14907	14367	16469.3
2	water , consumption	13,800	13,752	14,596	13,458	13,995	13,745	13,238	13,875	13,864	13,838	13,876	13,798	13,820
3	water loss	4,776	274	328	2,561	75	3,845	2,701	5,284	4,625	5,728	1,031	569	2,650
4	water loss in %	25.7105943	1.95351	2.1978	15.987	0.533	21.85	16.94	27.57	25.01	29.27	6.916	3.960	14.827

Table9-4 Monthly Total Water Production, Consumption and Loss for the Year 2015

No.	Type	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
1	water production	19883	18918	19556	23057	24114	25139	19981	22268	20389	22783	19883	18918	21240.75
2	water , consumption	17,106	17,118	17,113	17,100	17,098	17,300	17,204	17,152	17,269	17,766	17,106	17,118	17,204
3	water loss	2,777	1,800	2,443	5,957	7,016	7,839	2,777	5,116	3,120	5,017	2,777	1,800	4,037
4	water loss in %	13.9667052	9.51475	12.4923	25.836	29.095	31.18	13.89	22.97	15.30	22.02	13.96	9.514	18.3137

Table 9-5 Monthly Total Water Production, Consumption and Loss for the Year 2016

No.	Type	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
1	water production	23667	23867	22346	22465	21903	20647	21053	23369	24028	26602	26177	20628	23062.7
2	water , consumption	19749	20280	19583	19754	20918	19290	19594	19477	19658	19578	19511	19688	19756.7
3	water loss	3918	3587	2763	2711	985	1357	1459	3892	4370	7024	6666	940	3306
4	water loss in %	16.5546964	15.0291	12.3646	12.0677	4.4971	6.57238	6.9301	16.65	18.18	26.40	25.46	4.556	13.773

Table 9-6 Monthly Total Water Production, Consumption and Loss for the Year 2017

No.	Type	Jan.	Feb.	Mar.	Apr.	Ma.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annually
1	water production	43254	39289	40651	55324	56061	46532	14154	14842	42569	38953	42785	42338	476752
2	water , consumption	40510	35884	37171	45550	42861	37361	10407	13344	38957	38038	38561	36849	415493
3	water loss	2744	3405	3480	9774	13200	9171	3747	1498	3612	915	4224	5489	61259
4	water loss in %	6.34392	8.66655	8.56068	17.6668	23.5458	19.709	26.4731	10.093	8.4850	2.348	9.872	12.96	12.8492

Appendix 10 List of Figures

Figure 10-1 the measurement of PH/Toc /TDS/EC.

Site visit **GPS reading**

Pressure measurement

Figure 10-2 Site Visit, GPS Reading and pressure measurement.

Titration

Result of test

Figure 10-3 Measurement of Total hardness in the laboratory

Figure10-4 Measurement of turbidity

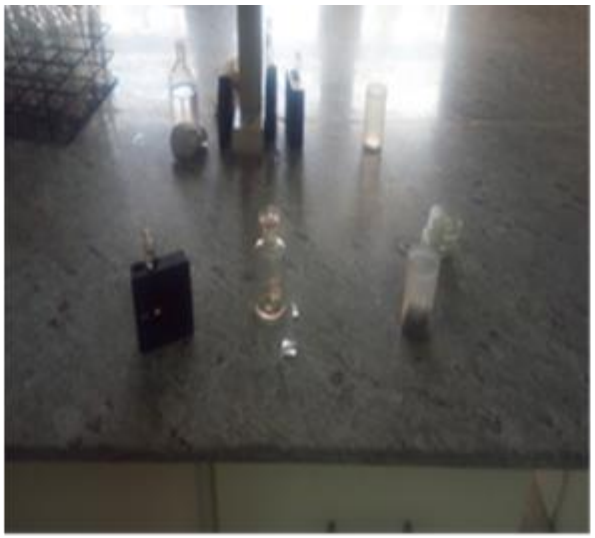


Figure 10-4 Measurement of free residual chlorine

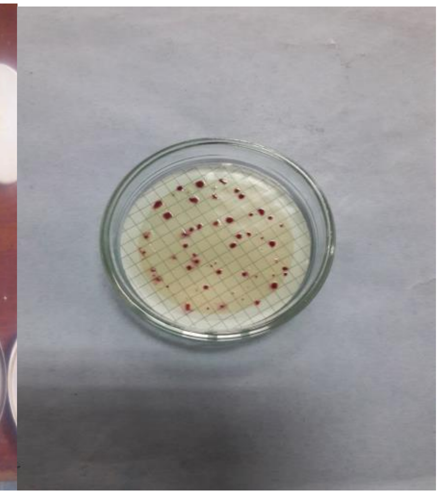


Figure10-5 Membrane filtration technique

Result